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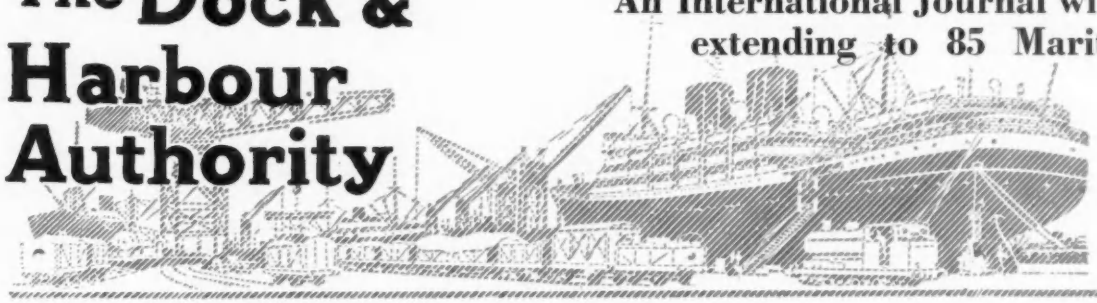

The St. Lawrence Seaway and Power Project

To commemorate the opening, on the 26th June, 1959, of the St. Lawrence Seaway by H.M. Queen Elizabeth and President Eisenhower, we are publishing in this issue a series of articles, some describing the engineering construction works and others giving details of the facilities at a number of ports along the Seaway which are now able to accept ocean-going ships of deeper draft.

The official opening marks the realisation of a project conceived more than a century ago. As early as 1825, the Hon. Robert Young called attention to the advantages of an inland waterway from the Atlantic to the Great Lakes. Another name famous among protagonists for the scheme is that of Thomas C. Keefer who, in 1887, became the first president of the Canadian Society of Civil Engineers (later the Engineering Institute of Canada). Keefer was responsible for a number of river engineering projects and designed many canals to improve communications between the St. Lawrence River and the Great Lakes.

Shortly before the First World War, the Canadian Government undertook the deepening of the Welland Ship Canal. This work was completed in 1932 and provided a depth of 25-ft. By the end of this year, the depth will have been increased to 27-ft. throughout, but even this improvement is not expected to be sufficient to cope with the anticipated increase in the volume of shipping. It is therefore likely that a duplicate canal will be needed within the next decade.

Coinciding with the need for improved navigation facilities on the Seaway was a demand for increased electric power to foster industrial development. The political intrigues which preceded the agreement to combine the navigation and hydro-electric schemes, and details of the engineering works undertaken exclusively for electrical power, are outside the purview of this Journal. The combined scheme has, however, involved many works for the purpose of improving navigation and also harnessing the waters of the St. Lawrence for the supply of power to extensive areas of Canada and the United States, and some of these are described in the following pages. The dual undertaking of building a canal system and providing for power development involved a number of secondary complications and large areas of land adjacent to the St. Lawrence River had to be flooded to produce the necessary water reservoirs feeding the generator turbines. This involved evacuating towns and villages and abandoning railway tracks and highways. At the same time, there had to be considerable re-building, all of which was ancillary to the main work.

As far as the economic prospects of the Seaway are concerned, these are anticipated to be far-reaching and have been outlined by Mr. B. J. Roberts, Chairman of the St. Lawrence Seaway Authority, to whom we are indebted for the following comments.

" The traffic through the new Seaway is expected to be of the same general character as that which has been passing through the old St. Lawrence canals and the Welland canal. It is estimated that 10 to 12 per cent. will be general cargo and the balance bulk cargo, largely made up of iron ore, grain, coal, petroleum products and forest products.

" It has been estimated that following the opening of the Seaway, cargo tonnages will amount to 25,000,000 tons a year, or about double that now passing through the old St. Lawrence canals, the increase being primarily due to anticipated greater volumes of iron ore and grain, including U.S. grain, and other bulk products. Subsequent increases in traffic are expected to bring the total to 50,000,000 tons a year by the end of a 10-year period. Similarly, for the Welland canal, the traffic is expected to rise from the current 23,000,000 tons and to reach its maximum capacity of 60,000,000 tons after 10 years.

" The new deeper channels with fewer but larger locks will provide a basis for the further growth and development of the St. Lawrence and Great Lakes hinterland. A number of ports in Canada and the United States are investing many millions of dollars for the development of water approaches and port facilities in order to accommodate larger vessels.

" The grain trade of Canada and the United States will undergo revolutionary changes in the long-established marketing pattern. Nearly all vessels now being built for the bulk trades are of the laker variety, up to 700-ft. long, and some smaller vessels are being lengthened to increase their carrying capacity. The former transfer of export grain from large " upper lakers " to small 250-ft. " canallers " at such points as Prescott and Port Colborne will, in the main, be a thing of the past. Most of these small canallers are quite old and will not be able to compete in the grain trade with the new 700-ft. vessels with their attendant economies. They will therefore either be scrapped or transferred to other trades. Under the old system it required 7 canallers operating between Prescott and Montreal to keep pace with one large vessel bringing grain from the Lakehead to Prescott. Now with the increased capacity of the Seaway, the same large vessel will be able to carry grain all the way through to Montreal, or even farther down the Lower St. Lawrence.

" A question of vital interest is that of the trans-shipment from laker to ocean vessels. Where will it take place? In the past the predominant movement has been by water to Montreal and other St. Lawrence River ports, either direct or by trans-

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shipment above the St. Lawrence canals. The grain delivered to the Georgian Bay ports in the Fall of the year has, in the past, moved through the winter months to Saint John and Halifax, and this movement will no doubt continue. It is expected that water trans-shipment in the Lakes area will be greatly reduced or eliminated. Elevators at such places as Port Colborne could continue to supply grain to ore vessels returning to Seven Islands, but this would require the absorption of the additional costs. Recently a United States grain company announced its intention to establish a grain elevator at Baie Comeau on the Lower St. Lawrence 225 miles below Quebec City. This facility is expected to attract a considerable volume of new traffic in United States grain. It will in addition be required to handle Canadian grain, and in view of its location near to ocean shipping lanes may contribute to alteration of the Canadian grain movement.

" The canal movement of iron ore from Seven Islands to Lake Erie was 2.2 million tons in 1957. In the past several years this traffic has come as far as Contrecoeur, just below Montreal in ocean-size vessels, and has been carried upstream to Lake Erie in " canallers." On the Seaway, large 700-ft. vessels will be able to effect the movement from Seven Islands or from Shelter Bay, to Lake Ontario or Lake Erie without trans-shipment.

" A sustained demand for iron ore holds prospects for greatly increased tonnages of this product through the Seaway, although it must be recognised that other routes for the transportation of Quebec-Labrador iron ore to certain interior sections of the United States will be in competition.

" Other bulk cargo should enjoy advantages from the new waterway, and with a general growth of industry this traffic should expand appreciably. Domestic package freight has moved on the lakes above Prescott quite economically in recent years in vessels too large for the old canals. In the years ahead this traffic should also show an appreciable growth.

" Forward strides are expected in the general cargo trade, that is, import and export package freight traffic with overseas countries. This movement has grown steadily during the past ten years to about 800,000 tons in 1957. Various shipping services to both U.S. and Canadian lake ports have been established in anticipation of the opening of the Seaway. Further developments in this field will be watched with closest interest, as it involves an area of keen competition with other transportation agencies, bringing into play such factors as regularity of services, adequate and efficient port terminals and the extent to which land transportation systems are prepared to meet water competition.

" Not all Great Lakes ports will enjoy the full advantage of the new Seaway depths. Many do not have harbour depths, port facilities nor traffic to attract the large vessels. The major inland ports of Canada and the United States are proceeding with programmes which will enable them to serve foreign trade.

" Fort William and Port Arthur are organising a joint Harbour Commission designed to produce a co-ordinated development of the port area as a gateway to the West. Sarnia, the great petrochemical centre on the St. Clair River, and Windsor, with all its automotive industry, are likewise contemplating improvements.

" The Seaway has been developed to meet the needs of the expanding industry and trade of the interior of Canada and the United States. All signs point to its exploitation to the full. This does not mean that its potentialities will be realised as soon as some may expect, or that relatively small harbours on the lakes will rapidly blossom into great ports."

The American ports likely to be affected by the opening of the St. Lawrence Seaway to ocean shipping appear to have been more cautious in their preparations to attract future trade than have their Canadian counterparts. Many of them have detailed plans in hand for future developments, but prefer to " wait and see " before committing themselves to expenses which may prove to be unjustified. Their reasons have been discussed, inter alia, in a symposium held by the Great Lakes Commission on port development and administration. It is essential to realise that in the past the majority of the Lake ports have been solely concerned with domestic trade and have not come into contact with international shipping. Further, few of them at present have any public port facilities, their wharves being owned by private companies for the handling of specific commodities. It has therefore been difficult for the various port agencies to get finance and support for development schemes without a sure promise of resultant trade. The weakness of this type of port administration was emphasised at the Symposium by Mr. Paul A. Amundsen, Executive Director of the American Association of Port Authorities.

" There are many areas on the Great Lakes where the very concept of public port development is under open challenge, or at least on trial. That is understandable if one understands mid-western thinking. This is the heart of producing America. It is the stronghold of private enterprise and there is no history here of conscious dependence on public port development. The natural reaction has been to let private industry build the piers. But there is not any profit to private capital in new-built general cargo marine terminals. Private industry cannot obtain long-term financing at the same attractive interest rates as can a public agency, nor can it afford the long wait for return on this investment while new cargo patterns are being established. It also lacks the legal power to make or acquire land on a cheap basis.

" It is not generally appreciated that all the functions of the public port agency are aimed to the benefit of private industry. Indeed, much new marine terminal building is pre-leased before construction as part of the public financing arrangement. In the development of most seaports, there has been original public investment in the form of a general obligation bond issue or a local tax levy with a gradual trend towards revenue financing, as a sufficient base of operating revenues has been built up over the years. This is the type of pattern which, in general, will take place on the Great Lakes over the next thirty to forty years.

" This game is played for big stakes. The Port of New York Authority's answer to the Seaway Act was to purchase several miles of Brooklyn waterfront and proceed with the building of $100 million worth of new marine terminals, and to contract with the City of Elizabeth, N.J., adjoining Port Newark, for the development of an entirely new port in that area of New York Harbour. Seaboard ports of the United States have spent over $700 million on new port facilities since 1946. During the same period Great Lakes ports have spent over $147 million in port facilities. Though that is a nice figure, I would say that in terms of construction, the Seaway has stimulated more new marine terminal building on the seaboard than it has on the Lakes."

Mr. Amundsen concludes his paper with the statement that " Major cities on the Great Lakes need much more unity on port development matters, with the leadership of the business community solidly allied behind development of the port. This is much more difficult in a major industrial centre than it is in a small port city, partly because of natural factionalism and partly because direct dependence upon shipping is not so apparent to the individual resident or businessman of a major metropolis. How to get cargo and how to develop sailings is lore that will have to be acquired, but on the Great Lakes, most ports start out in Seaway traffic with the advantage of a built-in industrial hinterland."

Our readers will no doubt appreciate that it has been impossible in this issue either to give a description of every port on the Seaway or to describe many of the engineering feats which have helped to make the opening of the Seaway possible. However, it is hoped that the following pages will be found of interest and will give a representative impression of the new St. Lawrence Seaway and its facilities.

Canadian Features of Navigation Works

By L. H. BURPEE, M.E.I.C.
(Deputy Chief Engineer, The St. Lawrence Seaway Authority, Montreal)

The 190-mile St. Lawrence Seaway from Montreal to Kingston opened for traffic at Montreal on Saturday, April 25th, and the old All-Canadian 14-ft. canal system has been abandoned except for local uses. There are seven locks in the new Seaway, of which five are Canadian. For the past sixty years the controlling dimensions of the locks of the St. Lawrence River Canals have limited the size of ships which could ascend from Montreal to Lake Ontario to 240-ft. in length and 43-ft. in width. The 28-mile Welland Ship Canal with its eight locks and total lift of 326-ft. was completed by Canada in 1932 between Lake Ontario (mean water level 246) and Lake Erie (mean water level 572). It cuts across the Niagara Peninsula and permitted the large bulk cargo ships of the Upper Great Lakes to come down to Lake Ontario, and it also provided the largest single part of the future "Seaway." During 1919, in the early stages of the Welland construction, negotiations were started between the United States and Canada towards joint development of the International Rapids Section of the St. Lawrence River for navigation and power. It was not until the early summer of 1954 that all International problems had been resolved and work could proceed.

The navigation and power works on the St. Lawrence River have cost over one billion dollars during the past five years, and have been constructed by two United States and three Canadian public bodies. In the International Rapids Section there have been the United States navigation works by the Saint Lawrence Seaway Development Corporation, the Canadian navigation works by The St. Lawrence Seaway Authority, the United States power works by The Power Authority of the State of New York, and the Canadian power works by The Hydro Electric Power Commission of Ontario. In the remaining sections of the river downstream, which are entirely in Canada, the works have been constructed by The St. Lawrence Seaway Authority and by the Quebec Hydro Electric Commission.

Approximately 71 per cent (by cost) of the navigation works between Montreal and Lake Ontario are in Canada. This is the part of the Seaway which will be described herein. The plan on page 40 shows the Great Lakes area, and an enlarged scale map of the St. Lawrence River from Montreal Harbour to Lake Ontario.

The Canadian Seaway locks are similar in their essential dimensions and arrangements to those on the Welland Ship Canal, which are 80-ft. wide, have 30-ft. depth on the sills at low water level, and have a length of 765-ft. from breastwall to fender, or between fenders. The two United States locks have been built to the same dimensions. The size of ships to be passed is indicated by the following extract from "Seaway Regulations:"

"Subject to these Regulations, every vessel that does not exceed 715-ft. in overall length and 72-ft. in beam may transit the Seaway during the navigation season.

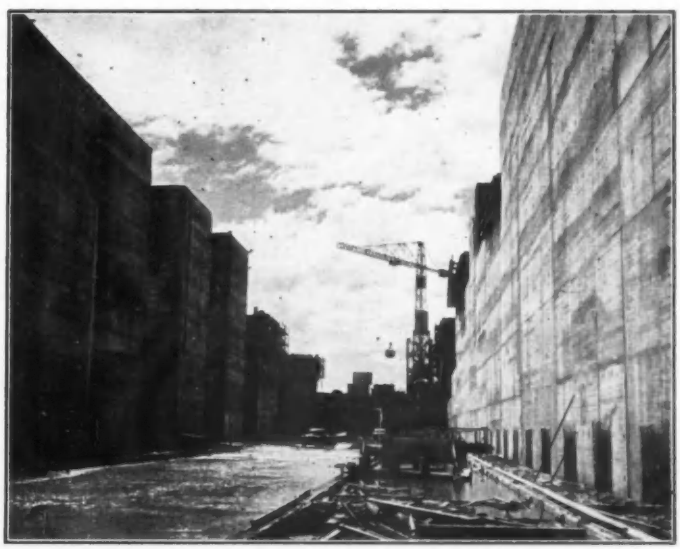
"Subject to these Regulations, vessels exceeding 715-ft. in overall length and 72-ft. in beam but not exceeding 730-ft. in overall length and 75-ft. in beam may, with special instruction from the Authority, transit the Seaway during the navigation season."

All Seaway channels have a controlling depth of not less than 27-ft. at low water level, and the minimum width is 200-ft. at the bottom when confined between two embankments. When the channel is flanked by only one embankment the minimum bottom width is 300-ft., and in dredged river or lake channels with no side bank, the minimum bottom width will be 450-ft. Some of the dredged channels will not be entirely completed and swept until the latter part of 1959, and there are restricted widths temporarily in a few places.

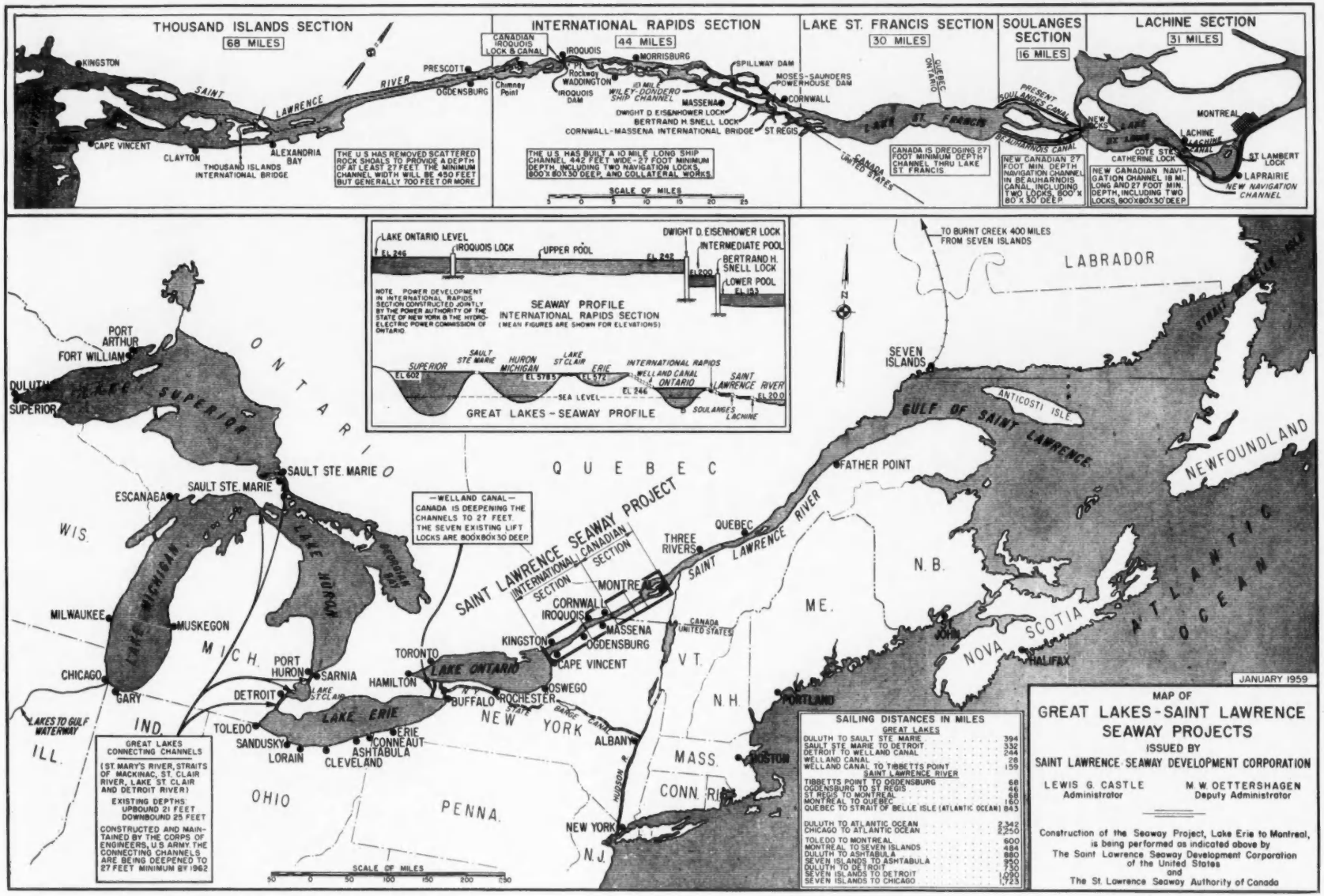
The entrance to the Seaway is a half-mile below Jacques Cartier Bridge and within the limits of the Harbour of Montreal which extends for more than 10 miles along the north side of the river. The entrance to the Seaway is opposite the upper end of the harbour. An 18½-mile canal has been constructed along the south shore of the river with two lift locks to overcome the 50-ft. drop in the Lachine Rapids.

Jacques Cartier bridge is the most important highway route crossing the river from Montreal to the South Shore. It was constructed with a high-level span over the harbour, that is to say, over the north channel between St. Helen's Island and the City of Montreal. The plans for the Seaway at the time of construction of this bridge (completed 30 years ago) provided for a location along the north side of the river. When

[Photo by Hans van der Aa]
View of St. Lambert Lock.



[Photo by Hans van der Aa]
Côte Ste-Catherine Lock during construction.


THOUSAND ISLANDS SECTION
68 MILES
KINGSTON
PRESCOTT
OGDENSBURG
SAINT LAWRENCE RIVER
CAPE VINCENT
CLAYTON
THOUSAND ISLANDS INTERNATIONAL BRIDGE
ALEXANDRIA BAY
THE U.S. HAS REMOVED SCATTERED ROCK SHOALS TO PROVIDE A DEPTH OF AT LEAST 27 FEET. THE MINIMUM CHANNEL WIDTH WILL BE 450 FEET BUT GENERALLY 700 FEET OR MORE.
INTERNATIONAL RAPIDS SECTION
44 MILES
CANADIAN IROQUOIS LOCK & CANAL
IROQUOIS
MORRISBURG
Chimney Point
Rockway
WADDINGTON
IROQUOIS DAM
45 MILE WILEY-DONDERO SHIP CHANNEL
SPILLWAY DAM
MOSES-SAUNDERS POWERHOUSE DAM
MASSENA
DWIGHT D EISENHOWER LOCK
BERTRAND H SNELL LOCK
CORNWALL-MASSENA INTERNATIONAL BRIDGE
CORNWALL
ST REGIS
THE U.S. HAS BUILT A 10 MILE LONG SHIP CHANNEL 442 FEET WIDE-27 FOOT MINIMUM DEPTH, INCLUDING TWO NAVIGATION LOCKS, 800'x80'x30' DEEP, AND COLLATERAL WORKS.
SCALE OF MILES
LAKE ST. FRANCIS SECTION
30 MILES
QUEBEC ONTARIO
LAKE ST FRANCIS
CANADA UNITED STATES
CANADA IS DREDGING 27 FOOT MINIMUM DEPTH CHANNEL THRU LAKE ST FRANCIS
SOULANGES SECTION
16 MILES
PRESENT SOULANGES CANAL
NEW LOCKS
LAKE ST LOUIS
BEAUHARNOIS CANAL
NEW CANADIAN 27 FOOT MIN. DEPTH NAVIGATION CHANNEL IN BEAUHARNOIS CANAL, INCLUDING TWO LOCKS, 600' x 80' x 30' DEEP
LACHINE SECTION
31 MILES
MONTREAL
LACHINE CANAL
COTE STE CATHERINE LOCK
ST LAMBERT LOCK
LAPRAIRIE
NEW NAVIGATION CHANNEL
NEW CANADIAN NAVIGATION CHANNEL 18 MI. LONG AND 27 FOOT MIN. DEPTH, INCLUDING TWO LOCKS, 800x80x30' DEEP
LAKE ONTARIO LEVEL
IROQUOIS LOCK
UPPER POOL
EL 246
EL 242
DWIGHT D. EISENHOWER LOCK
INTERMEDIATE POOL
BERTRAND H. SNELL LOCK
EL 200
LOWER POOL
EL 193
NOTE: POWER DEVELOPMENT IN INTERNATIONAL RAPIDS SECTION CONSTRUCTED JOINTLY BY THE POWER AUTHORITY OF THE STATE OF NEW YORK & THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.
SEAWAY PROFILE
INTERNATIONAL RAPIDS SECTION
(MEAN FIGURES ARE SHOWN FOR ELEVATIONS)
SUPERIOR
SAULT STE MARIE
HURON
MICHIGAN
LAKE ST CLAIR
ERIE
INTERNATIONAL RAPIDS
WELLAND CANAL
ONTARIO
SAINT LAWRENCE RIVER
EL 602
EL 578.5
EL 572
EL 246
EL 20.0
SEA LEVEL
SOULANGES
LACHINE
GREAT LAKES - SEAWAY PROFILE
TO BURNT CREEK 400 MILES FROM SEVEN ISLANDS
LABRADOR
STRAIT OF BELLE ISLE
SEVEN ISLANDS
ANTICOSTI ISLE
GULF OF SAINT LAWRENCE
NEWFOUNDLAND
ATLANTIC OCEAN
FATHER POINT
QUEBEC
THREE RIVERS
SAINT LAWRENCE RIVER
N.B.
ME.
NOVA SCOTIA
HALIFAX
PORTLAND
JOHN
PORT ARTHUR
FORT WILLIAM
DULUTH
SUPERIOR
LAKE SUPERIOR
ONTARIO
QUEBEC
SAULT STE. MARIE
ESCANABA
WIS.
LAKE MICHIGAN
LAKE HURON
GEORGIAN BAY
MILWAUKEE
MUSKEGON
MICH.
CHICAGO
GARY
IND.
ILL.
LAKES TO GULF WATERWAY
PORT HURON
SARNIA
LAKE ST CLAIR
DETROIT
TOLEDO
SANDUSKY
LORAIN
CLEVELAND
ERIE
CONNEAUT
ASHTABULA
OHIO
PENNA.
LAKE ERIE
TORONTO
HAMILTON
LAKE ONTARIO
BUFFALO
ROCHESTER
OSWEGO
N.Y.
NEW YORK STATE BARGE CANAL
ALBANY
NEW YORK
N.J.
HUDSON R.
SAINT LAWRENCE SEAWAY PROJECT
INTERNATIONAL SECTION
CANADIAN SECTION
—WELLAND CANAL—
CANADA IS DEEPENING THE CHANNELS TO 27 FEET. THE SEVEN EXISTING LIFT LOCKS ARE 800X80X30 DEEP.
CORNWALL
IROQUOIS
MONTREAL
MASSENA
OGDENSBURG
KINGSTON
CAPE VINCENT
CANADA
UNITED STATES
VT.
N.H.
MASS.
CONN. R.
R.I.
BOSTON
GREAT LAKES CONNECTING CHANNELS
(ST. MARY'S RIVER, STRAITS OF MACKINAC, ST. CLAIR RIVER, LAKE ST. CLAIR AND DETROIT RIVER)
EXISTING DEPTHS:
UPBOUND 21 FEET
DOWNBOUND 25 FEET
CONSTRUCTED AND MAINTAINED BY THE CORPS OF ENGINEERS, U.S. ARMY. THE CONNECTING CHANNELS ARE BEING DEEPENED TO 27 FEET MINIMUM BY 1962
SCALE OF MILES
SAILING DISTANCES IN MILES
GREAT LAKES
DULUTH TO SAULT STE. MARIE 394
SAULT STE. MARIE TO DETROIT 332
DETROIT TO WELLAND CANAL 244
WELLAND CANAL 28
WELLAND CANAL TO TIBBETTS POINT 159
SAINT LAWRENCE RIVER
TIBBETTS POINT TO OGDENSBURG 68
OGDENSBURG TO ST. REGIS 46
ST. REGIS TO MONTREAL 68
MONTREAL TO QUEBEC 160
QUEBEC TO STRAIT OF BELLE ISLE (ATLANTIC OCEAN) 843
DULUTH TO ATLANTIC OCEAN 2,342
CHICAGO TO ATLANTIC OCEAN 2,250
TOLEDO TO MONTREAL 600
MONTREAL TO SEVEN ISLANDS 484
DULUTH TO ASHTABULA 880
SEVEN ISLANDS TO ASHTABULA 950
DULUTH TO DETROIT 730
SEVEN ISLANDS TO DETROIT 1,090
SEVEN ISLANDS TO CHICAGO 1,723
JANUARY 1959
MAP OF
GREAT LAKES - SAINT LAWRENCE SEAWAY PROJECTS
ISSUED BY
SAINT LAWRENCE SEAWAY DEVELOPMENT CORPORATION
LEWIS G. CASTLE
Administrator
M.W. OETTERSHAGEN
Deputy Administrator
Construction of the Seaway Project, Lake Erie to Montreal, is being performed as indicated above by The Saint Lawrence Seaway Development Corporation of the United States and The St. Lawrence Seaway Authority of Canada

[Photo by Hans van der Aa]

Honoré Mercier Bridge and Canadian Pacific Railway Bridges seen from the air, with Lake St. Louis in the distance.

Lower and Upper Beauharnois Locks under construction with Lake St. Louis in the foreground. To the left is the Quebec Hydro power development with its 3,200-ft. wide canal.

other factors made it desirable to construct the Seaway along the south shore, the raising of the south part of this bridge became a necessity. At the Seaway channel the bridge was jacked up 40-ft. and an additional 40-ft. of clearance was gained by constructing a new through truss. The new span was erected on falsework alongside, and the only interruption to use of the bridge was a 6-hour period in which the old span was moved out and the new one moved in.

St. Lambert Lock has a lift varying from 5-ft. to 20-ft. depending on the water elevation of the river in the harbour. This lock is immediately upstream from Victoria Bridge, which carries the double track main line crossing of the Canadian National Railway and which also carries heavy highway traffic. By locating the lock immediately upstream from the bridge it was possible to provide for uninterrupted railway and highway traffic by having duplicate lift bridges, one at each end of the lock. Normally, all traffic uses the downstream lift span (which is the new south span of Victoria Bridge). For an upbound ship to enter the lock or a downbound ship to leave it, the Victoria Bridge lift span will be raised and all traffic will be temporarily diverted to the upstream bridge. The alternate routes are in use now to maintain uninterrupted highway traffic, but the alternate railway structure extending out into the river will not be completed until 1961.

Côte Ste-Catherine Lock is eight miles upstream from St. Lambert Lock, and has a lift varying from 30-ft. to 40-ft., depending on the natural water elevation on Lake St. Louis.

These two locks and the connecting canal have been constructed in the bed of the river using the excavated materials to build the dyke. This work required cofferdams extending for over ten miles.

Upstream from Côte Ste-Catherine Lock the canal has been excavated to the south of the river to bypass the main part of the Lachine Rapids. Near the upper end of this canal are the crossings of the double track main line of the Canadian Pacific Railway and the Honoré Mercier Highway Bridge. Two separate single-track lift bridges have been provided for the railway in order to reduce to a minimum the possibility of railway or Seaway traffic interference due to bridge maintenance. The highway bridge has an entirely new south approach which provides a high-level overhead span crossing the Seaway channel and separate dual highways leading east and west.

For 15 miles the Seaway channel uses Lake St. Louis, which required only dredging.

The Soulanges Section of the river has a drop of 83-ft. in 15 miles. The Seaway makes use of the canal constructed nearly 30 years ago by the Beauharnois Power Company (now a part of Quebec-Hydro) under an agreement with the Government of Canada by which the work was designed to standards suitable for use as part of the future Seaway. The Beauharnois Power Canal is 3,200-ft. wide and was constructed between 1929 and 1932 as a main feature of the power development. It was planned with dimensions suitable to ultimately divert the entire normal flow of the St. Lawrence River. It was also planned that the 600-ft. width of deep water along the north bank would be the future Seaway channel. Four bridges were constructed at that time, one for a highway across the tailrace, one for a railway just above the power house, and two combined railway-highway structures across the canal. Piers suitable for future lift spans were provided at these two bridges. As features of the Seaway it has been necessary to construct a 4-lane highway tunnel under the lower lock, a railway swing span over the upper lock, and to build the lift spans in the two combined railway-highway bridges. Two locks have been constructed to provide the lift from Lake St. Louis to Lake St. Francis level. Both these lakes are a widening of the St. Lawrence River and are not indicated on the main plan but are shown on the enlarge scale map.

Upstream from the Beauharnois Power Canal, the Seaway follows Lake St. Francis for 30 miles to the foot of the International Rapids Section. Dredging only was required here.

The St. Lawrence River becomes the International Boundary at the upper end of Lake St. Francis, and the boundary follows roughly up the centre of the channel south of Cornwall Island. Dredging in the channel and straightening of the river banks for the four-mile length of the South Cornwall Channel has been shared between the United States and Canada.

To overcome the 87-ft. head at the International Power Development, the Saint Lawrence Seaway Development Corporation (United States) has constructed the Wiley-Dondero Canal and the Snell and and Eisenhower Locks to make the lift up to the level of the new Lake St. Lawrence.

For 30 miles upstream of the exit from the United States Canal into Lake St. Law-

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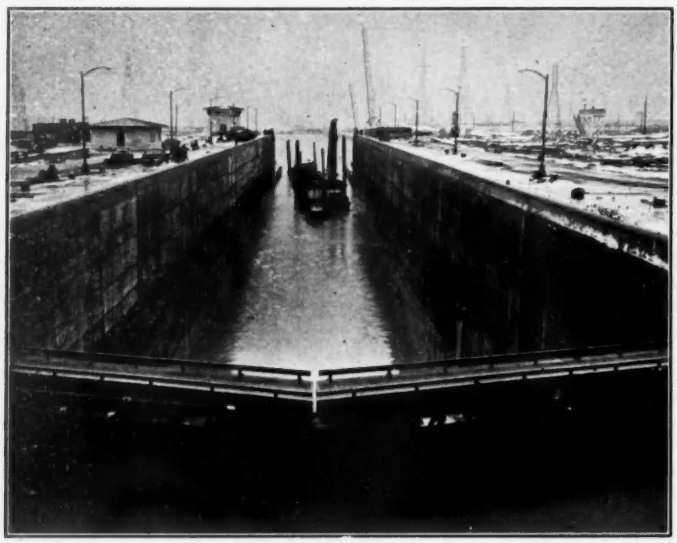

[Photo by Hans van der Aa]
A dredging fleet moving through Upper Beauharnois Lock.

[Photo by Hans van der Aa]
Aerial view of Iroquois Lock showing Iroquois Control Dam on the right.

rence the Seaway makes use of the deep water behind the dam and of channels provided by the power agencies.

At Iroquois, the lock to bypass the Control Dam is on the Canadian side and has been constructed by the Authority. The normal lift at this lock will vary from a few inches to several feet depending on water levels and regulated flow requirements. It is of interest to note that for several months in 1958 during construction of the power development, the Iroquois Lock was operated at a lift of 18-ft.

The equipment at each lock includes the lock gates, valves to fill and empty the lock, wire rope fenders to protect the gates from damage by a ship impact, steel stoplogs for emergency or maintenance closures of the lock entrances, and unwatering pumps for maintenance. Also included are the necessary mooring bollards and line haulers.

Lock gates of the mitre type and sector type are being used. The operating gates for the four locks between Montreal and Lake St. Francis are mitre type. The operating gates for Iroquois Lock are of the sector type, which can be opened and closed against a head of water, and which are the only means of filling and emptying this lock. Sector gates have been installed at Côte Ste-Catherine and Upper Beauharnois Locks as precautions in case of damage to the mitre gates.

The four Canadian locks, other than Iroquoise, have been designed with side culverts and ports for filling and emptying, with 12-ft. by 14-ft. sector valves for controlling the flow to fill or empty in about 12 minutes.

Construction of the Canadian parts of the navigation works actually started with the awarding of contract No. 1 in October 1954, and the work was essentially completed by November 1958. During that time 75,000,000 cu. yds. of materials were excavated and over 2,000,000 cu. yds. of concrete were placed in the structures. Lock equipment installations and bridge steel erection started during 1957, and were sufficiently completed by November 1958 so that all channels could be flooded and all locks could be tested. Minor work was continued throughout the winter, and the Seaway was ready for use by mid-April. A late break-up of ice delayed the opening until April 25th.

The development of the St. Lawrence River for navigation has now been accomplished, and the power of the International Rapids and of the Rapids of the Soulanges Section have been fully developed. There still remains the undeveloped power of the Lachine Rapids, but all navigation works in this part of the river have been designed and constructed to permit the future use of this power when desired by Quebec Hydro.

The Port of Quebec

(Specially Contributed)

Deep water is the first requisite of a great port, along with advantageous geographical location, adequate and modern facilities, and safety of approach. Quebec has all these advantages. It is on tidewater and can be reached at any tide by the largest vessels using the St. Lawrence route.

In the harbour limits, extending from the Island of Orleans to Cap Rouge, a distance of fifteen miles, there is deep water, reaching depths of nearly 200-ft. at low tide in the centre of the channel. While depths of 35-ft. at low tide are available at most of the principal berths, docking with 40-ft. is also available. The harbour facilities are modern, have been planned with care and are being developed further to serve Quebec's steadily increasing overseas and coastal traffic, both passenger and freight. There are two main sections of wharves: the Princess Louise Docks and Wolfe's Cove Terminals.

The Canadian Pacific and Canadian National Railways provide rail connections to all parts of the Continent, while from Quebec good highways run in all directions.

The most easterly of the larger St. Lawrence ports, Quebec is advantageously located geographically, being 160 statute miles below Montreal. It is some 500 miles closer to Liverpool than is New York, a fact which is perhaps not sufficiently appreciated. Furthermore, on a trans-Atlantic trip, to or from Quebec, two days are spent on the sheltered Gulf and River St. Lawrence, thus cutting down the time actually spent on the ocean itself.

The National Transcontinental Railway has brought Quebec some 200 miles closer to Winnipeg and the wheat fields than formerly, and also gives Quebec direct

ESTD
1884
DAZE DEEP
DREDGING SPECIALISTS
Tilbury Contracting
& Dredging Co Ltd
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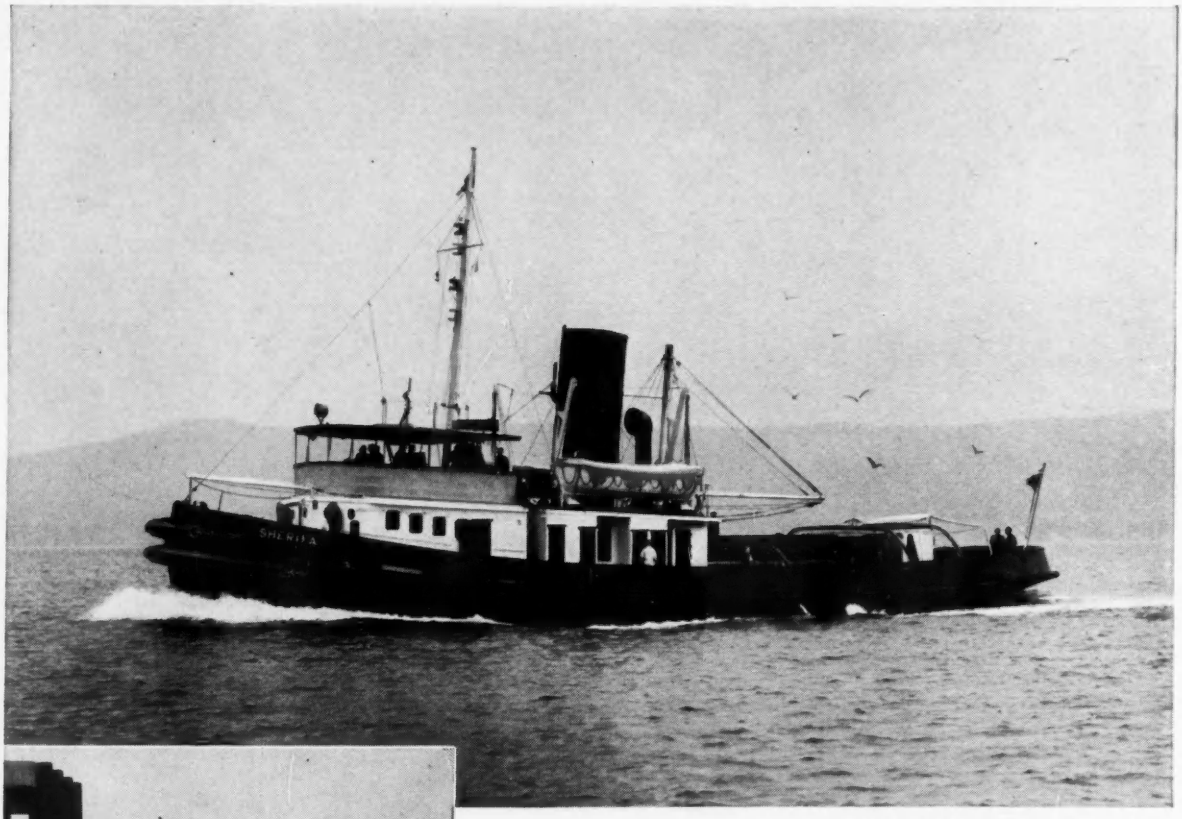

D/T 'SHERIFA', an ocean going tug built by Scott & Sons of Bowling, nr. Glasgow, for ship towing service in the Middle East.

D/T 'MERCEDES', one of three tugs for barge towing duties on the Thames recently built for the William Cory Group.

Effective fendering for every class of tug

OCEAN-GOING TUGS and small river tugs alike depend upon Goodyear rubber fenders for efficient hull protection. Able to compress to one third of their original diameter without damage, they cushion the blows and crushing impacts unavoidable in towage. Unlike conventional fendering materials, Goodyear fenders are virtually indestructible in normal service; they resist abrasion rotting and corrosion, and require no maintenance or attention. Neat, easily fitted and economical, they are made in a range of cylindrical, rectangular and D sections to suit all working boat applications. Sections may be preformed to the required profile and spigotted together to form an integral unit.

RUBBER FENDERS by

GOODYEAR

The Goodyear Tyre & Rubber Co. (Great Britain) Ltd., Industrial Rubber Products Department, Wolverhampton. Export Enquiries: 17 Stratton Street, London, W.1

connections with the rich mining regions of Northern Quebec and Ontario.

Role in the Canadian Economy

Served by the largest passenger liners using the St. Lawrence route, Quebec is also the natural supply centre for the Lower St. Lawrence North Shore. From Quebec an extensive business is done, not only by the larger coasting vessels operating as far as Labrador, Anticosti and Newfoundland, but also by numerous diesel-powered so-called "schooners." Nearly five thousand vessels of all types dock in the harbour each season. The harbour is open to ocean shipping from April to December while coastal vessels now run between Quebec and the Lower St. Lawrence on a small scale during the winter months.

The great iron ore discoveries in Northeastern Quebec and in Labrador are bound to stimulate commerce in the whole Quebec district in the years to come.

Quebec is also the port from which the asbestos is exported that has been mined in the Thetford Mines region, the greatest asbestos mining centre in the world.

With the opening of the St. Lawrence Seaway, this port has great possibilities as a port of trans-shipment between ocean-going freighters and the larger canal vessels.

The gateway to the trade of the interior of the Continent in earlier times, a great timber port in the days of sailing ships, a port through which three million immigrants have landed since 1860 and through which the movement of immigrants has again resumed considerable importance, Quebec Harbour has always played an important part in the commerce of Canada. Some of the largest warships in the world have visited it and today, regular passenger and freight services are operated, principally to Europe, but there are also sailings to other ports of the world, according to cargo tonnage offered.

Traffic of the Port

Over 4,700 vessels dock at Quebec Harbour each year, their net registered tonnage totalling nearly 7,000,000. Water-borne cargo tonnage unloaded from and loaded to vessels totals 4,000,000 tons. The most important commodities handled yearly are:

Petroleum fuel oil ...	1,000,000 tons
Grain, from 600,000 to	850,000 tons
Pulpwood	750,000 tons
Gasoline	380,000 tons
Coal	250,000 tons
Asbestos	190,000 tons
Newsprint paper ...	150,000 tons
Ores and Concentrates	150,000 tons
Cement	100,000 tons

The grain elevator is capable of delivering up to 28 million bushels in a year, and the port has a record for fast grain loading and unloading.

The Harbour Railway handles 35,000 revenue cars a year, and 100,000 passengers, both trans-Atlantic and coastwise, disembark from or embark on vessels in the harbour each season.

An interesting feature of the operations of the Cold Storage Fish House is the glazing by a special process each autumn of large quantities, reaching up to 900,000 pounds, of local eels for export both to Europe and the United States.

Two aerial views of the port and city of Quebec.

Modern Facilities

The facilities operated by the National Harbours Board, and which now represent an investment of over thirty million dollars, include over 20,000 lineal feet of quay wall providing 27 deep-sea and 14 coastal berths; 9 transit sheds with a total floor area of 700,000 square feet; 23 miles of standard gauge terminal railway served by diesel-electric locomotives operated by the Board and connecting with the two principal Canadian railways; a Grain Elevator with a storage capacity of 6,000,000 bushels; a modern Cold Storage Warehouse with a capacity of 500,000 cubic feet plus a Fish House with a capacity of one million pounds; a floating crane of 75-tons lifting capacity, and three locomotive cranes with capacities up to 38 tons. Deep-water berths are served by railway tracks, roadways, fresh water, electric power and oil bunkering lines.

At Lauzon, across the river from Quebec, the Department of Public Works operates the huge Champlain Dry Dock (1,150-ft. long by 120-ft. wide at the entrance), capable of taking the largest vessels, as well as the Lorne Dry Dock (600-ft. long by 62-ft. wide at the entrance). Two large private shipbuilding yards, which are also adequately equipped to make repairs of all kinds to vessels, and which operate

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their own marine railways and patent slips, are also located at Lauzon.

Development of the Harbour

In 1805 an Act of Parliament established "Trinity House," the first authority vested with the power of administering the Ports of Quebec and Montreal, and also having jurisdiction over the body of Pilots. In 1858 the Board of Quebec Harbour Commissioners was formed, and this body functioned simultaneously with "Trinity House" until 1876, when the powers still pertaining to "Trinity House" were transferred to the Quebec Harbour Commissioners. On October 1st, 1936, with the proclamation of the National Harbours Board Act, the former corporation was succeeded by the National Harbours Board, which now administers the principal seaports of Canada.

The first large development plan for the harbour was prepared by two eminent English engineers, Messrs. Kinnipple and Morris, in 1874. Work was started in 1877 on the construction of the Princess Louise Embankment, at the mouth of the St. Charles River. A Wet Dock or Inner Basin, 34 acres in area, and a Tidal Harbour or Outer Basin, 19 acres in area, separated by a Cross-Wall 960-ft. long and 155-ft. wide, were provided. Twin gates 64-ft. wide, providing access to the Inner Basin, and sufficient to permit the passage of large modern freighters, were put into operation in May, 1890, and the original gates and operating mechanism are still functioning efficiently today, as well as the sluice valves controlling the water in the Inner Basin. Pier No. 1 was completed in 1911. The widening of the St. Charles River wharves was completed in 1917. Transit sheds were erected from time to time as required. The Princess Louise Docks now accommodate principally freighters and the coasting trade.

Wolfe's Cove Terminals

The newer part of the harbour, designed with trans-Atlantic pasesnger traffic and the largest vessels more especially in mind, is known as Wolfe's Cove Terminals. The contractors started work in 1925 and the new facilities were inaugurated in 1931. These terminals have a total length of quay wall of 5,000-ft., and there is a double-deck, steel, concrete and brick shed, measuring 1,380-ft. by 100-ft. wide, known as Shed "A." Six railway tracks run parallel to the shed and are reached directly from the second deck by covered passageways without having to cross the rails themselves. These facilities ensure that passengers are conveyed very quickly from train to boat and vice versa. A large, modern building is being completed in rear of Shed "A" to expedite handling of customs and immigration.

Recent Development

As already stated, the facilities of the harbour are under constant study in order to provide for anticipated increases in traffic. The most recent construction is as follows:

A new berth to accommodate large tankers and provide an additional 900,000 square feet of marine terminal space for oil firms' storage tanks at Wolfe's Cove; reconstruction of Berth No. 8 at Pointe-à-Carcy, to serve both coastal and ocean traffic, and on which a modern transit shed will be erected; the erection of a 2,000,000 bushels capacity annex to the harbour's 4,000,000 bushel grain elevator, with a view to accommodating the large upper lakers expected to bring grain to Quebec upon the opening of the St. Lawrence Seaway; the widening and strengthening of Berth No. 18 to carry two travelling grain-unloading marine towers to serve the above-mentioned elevator annex. These towers have a combined unloading capacity of 72,000 bushels of grain per hour. It is also planned to replace Shed No. 19, serving the coastal trade, by a modern transit shed.

The City of Quebec

The City of Quebec now has a population of over 200,000 living within its limits, Greater Quebec claims 300,000 persons, while the surrounding municipalities bring the total to about 400,000.

Besides being the Provincial capital, Quebec is also an important commercial, manufacturing, educational, religious and military centre.

The principal products manufactured are: newsprint paper; boots, shoes and leather; tobacco, cigars and cigarettes; corsets; clothing; brewery products; fur goods; electrical goods; plumbing supplies; printing and publishing; cardboard boxes and paper bags; steelwork; slaughtering and meat packing; sanitary products; munitions; kitchenware; woollen knitted goods; rubber goods; furniture; bakery products and confectionery; etc.

The Port of Three Rivers

By L. ST. PIERRE (Port Manager)

Trois Rivières is located at the south of the St. Maurice River, the gateway to the St. Maurice Valley, a vast region rich in natural resources. Next to the Ottawa and the Saguenay, the St. Maurice is the largest tributary of the St. Lawrence, draining an area of 17,000 square miles on the eastern slope of the Laurentian plateau.

Trois Rivières, with a population of nearly 58,000, takes the name from the St. Maurice River which was called by Pontgravé "La Rivière des Trois Rivières," because the mouth of the river is divided by two narrow islands into three large channels. The first permanent settlement was established by Sieur de Laviolette in 1634 with the help of Jean Nicolet, the well-known explorer who first saw the western shores of the Great Lakes.

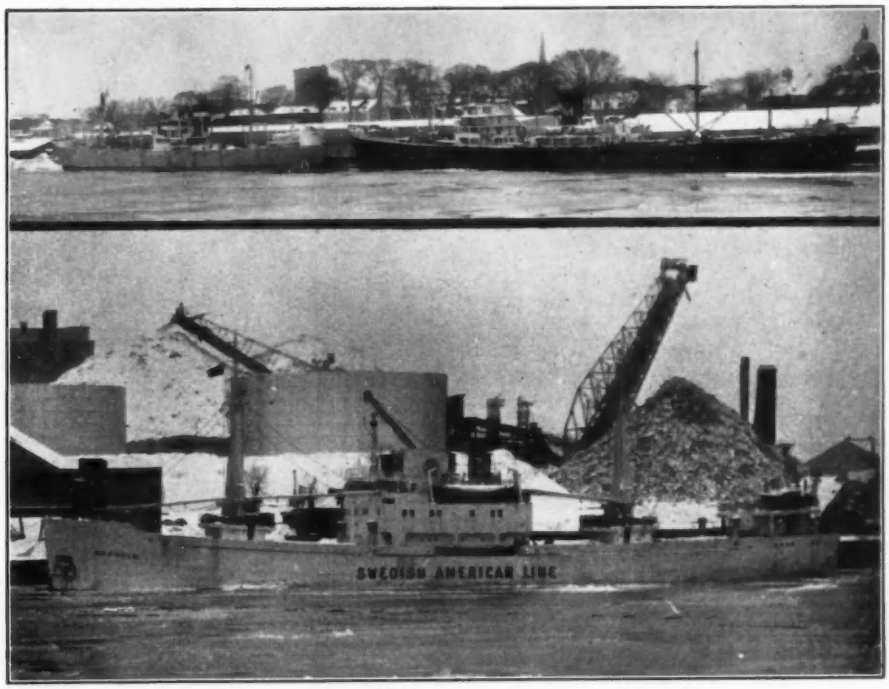
Trois Rivières was established chiefly as a centre for the widely extended fur trade, but it was also intended to serve as a barrier against incursions by the Indians and as an outpost, or advanced guard, to ensure the safety of Quebec where, at that time, the entire fortune of the colony was centred.

The first discovery of iron ore in Canada may be clearly traced to the year 1667. Although the Jesuit Fathers had been aware for a long time of the existence of mineral wealth at several points and particularly in their Seigneurie of Cap Madeleine, no attempt up to that time had been made to develop this new source of prosperity. In 1667, however, it was decided to explore for iron and other productive mines so that their discovery might serve as an inducement to stimulate immigration to the colony from France. In 1737 a company was formed to operate these mines on a large grant of land and the site of the St. Maurice Forges situated about eight miles north of the city.

In 1740 the mines were taken over by the Governor of France and managed very successfully. The manufactured articles from the Forges soon became known throughout the country, and large quantities of pig and bar iron were exported to France and England, where the St. Maurice iron was early admitted to compare favourably with the best iron produced in Europe. After the transfer of Canada to the British Crown in 1760, the mines continued to be worked under private lessees.

After 1760 all exports were sent to Great Britain and only goods of English manufacture were allowed to be imported so that, from this time, commerce was chiefly in the hands of English traders. Shipbuilding became a regular industry and a considerable number of vessels for river and ocean traffic were built in the port's yards.

From 1852 to 1880, numerous lumber mills were erected in the vicinity of Three Rivers, in particular 15 large concerns, all of which were centred on the port. To give some indication of the timber trade at this time, the Dominion Tables of the Trade and Navigation for 1875 lists 24 vessels aggregating 13,482 tons which cleared the port. In connection with the lumber trade, other industries developed in the vicinity. For instance, there were three mills for the manufacture of silk and thread spools; furniture and match factories; ship, railway and mining timber yards, etc.



Shipping and bulk handling facilities at Three Rivers.

The Port of To-day

The City of Three Rivers is served by a modern harbour where vessels of the deepest draft can load or discharge cargo. The Port is situated on the North Shore of the St. Lawrence River, about midway between Montreal and Quebec and serves a prosperous industrial and agricultural region, receiving raw materials and shipping manufactured commodities in large volume. Grain and other export products of Central and Western Canada and imports consigned to distant inland points, also pass over its wharves. Well-equipped with a number of wharves, transit sheds, handling equipment, and a modern grain elevator, it plays an important role in the economic life of Canada. Its navigation season begins in April and lasts approximately eight and a half months.

Three Rivers claims to be a very good centre for a considerable portion of the shipping trade of the St. Lawrence. It is situated immediately below Lake St. Peter at equal distance between the two largest cities of the St. Lawrence, and it is absolutely free from any material or marine obstruction. Vessels of every description can approach the wharves without fear of danger and without having recourse to any artificial channel or other protection. The harbour is large and the current very moderate (2½ to 9 miles per hour depending on season); there is no rise and fall of the tide of any consequence, and no breakwaters are required.

Skilled stevedores and workmen are always on hand to load vessels, while the shipmaster has a cheap market to purchase his supplies and provisions and where all the necessary articles for vessels and crews can be obtained.

Three Rivers is primarily a port City and the advantages it offers, as such, have been one of the reasons for its development since 1925. From that date to some fifteen years ago, its development was slow, but the Northern part of the district, the capital of which is Three Rivers, has witnessed recently great commercial development and the growth of several important industries which have helped the steadily increasing movement of traffic through the port.

Whilst the northern district was thus being developed, industry in Three Rivers grew rapidly, so much so that it became the greatest paper producing city in the world. Many companies, seeing the advantages its situation on the St. Lawrence River offered, erected paper and kraft mills. Under that impulse the Port grew with the City and soon became the second port in freight tonnage in the Province.

To-day, the total inward and outward cargo amounts to over 3,000,000 tons annually. This traffic is carried by some 350 ocean-going ships and 2,500 coastal or inland vessels with an aggregate net registered tonnage of approximately 2,000,000.

The grain elevator has a storage capacity of 3,800,000 bushels and is connected, by means of a grain gallery, with a storage annex of 3,000,000 bushels capacity. There are two grain berths, one equipped with a marine leg for discharging ships, and the other for loading ships. Maximum annual shipments amount to over 28,000,000 bushels.

Of the ten transit sheds provided, two are designed specifically for the shipment of newsprint and eight are general cargo sheds.

Trade at the port can be broken down under the following main headings:—

Exports: Newsprint, grain, asbestos, aluminum and chemical products.

Imports: Coal, pulpwood, sulphur, clay, etc.

Accommodation

There are 9,600 lineal feet of wharves, all of which are parallel to the River St. Lawrence Ship Channel. Average depth of water alongside all wharves at low water is from 30 to 35-ft. Commencing at the east end of the harbour front at the angle formed by the junction of the St. Maurice River with the St. Lawrence, the wharfage sections are as follows: (1) Canadian International Paper Company's Wharf, berthing length 1,320-ft.; handling facilities: four 2½ ton cranes for pulpwood, two coal towers of 200 tons per hour capacity. Wharf space being used for the storage of pulpwood and coal. (2) National Harbour Board Wharf: berthing length 1,700-ft.; 4 sheds of various dimensions on wharf, the largest 1A-1B (880-ft. x 160-ft.) having been specially built for the handling of newsprint by means of conveyors. Two 2½ ton hoists for paper, railway tracks, water-main, electric power and light. Connected to shed 1A-1B is shed No. 2 (305-ft. x 50-ft.) serving as an auxiliary for the storage of newsprint. Erected in 1954, Shed No. 3 (550-ft. x 100-ft.) offers to shipping interests the most modern facilities for the handling of general cargo. (3) C.S.L. wharf: berthing length 300-ft.; shed 350-ft. x 50-ft., electric light, no water-main, railway tracks 150-ft. from wharf, no cranes or hoists—storage facilities. (4) N.H.B. Wharf: berthing length 300-ft., electric light, railway tracks, 150-ft. distant, water-main, no cranes or hoists. (5) N.H.B. Wharf (quai Bureau) berthing length 2,000-ft. Part being used for the storage of coal, leased to St. Lawrence Coaling Limited, who occupy 375-ft. of

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wharf at the east end as a coal depot and operate 3 steam locomotive cranes for handling coal. Total capacity 2,000 tons per day. Shed No. 10 (400-ft. x 60-ft.), railway tracks, water-main, electric lights. Inaugurated in 1958, Shed No. 11 (550-ft. x 100-ft.) is the most recent example at the port of modern warehousing, loading and unloading facilities. (6) N.H.B. Wharf: berthing length 2,375-ft. includes a basin which contains 3 berths of 500-ft., 395-ft. and 600-ft. Two concrete sheds, 13 and 16, dimensions of each being 400-ft. x 60-ft. and a wood, asphalt-sheeted shed of 305-ft. x 50-ft., which offers storage for a wide variety of commodities. Railway tracks and water-main and electric power connections ensures efficient service. A grain elevator and annex of 6,800,000 bushel capacity, operated by a private concern, is operating on section 16. (7) N.H.B. Wharf: berthing length 925-ft., no sheds, equipped with rail tracks, water-main, electric light and power. This section is occupied by the Dominion Coal Company who owns and operates two steel Mead-Morrison discharging towers with a capacity of 700 tons per hour, used for coal storage and the unloading of bulk cargoes. (8) An extension of a 540-ft. wharf, to those existing, built in 1958, will provide Three Rivers Harbour with an open space wharf to meet future requirements.

Further to this improvement, the Three Rivers Grain and Elevator Company have announced the erection of two mobile grain unloading towers which will considerably improve Trois Rivières capacity in the handling of grain.

The River St. Lawrence Ship Channel has been dredged to 30-ft. at extreme low water level, average depth: 35-ft.

The Port of Montreal

By GUY BEAUDET (Port Manager)

General Description

The Port of Montreal is outstanding in many ways. It is rated as Canada's greatest port and one of the great harbours of the world, yet it is located 1,000 miles inland from the Atlantic Coast. Despite this inland location, it is closer to the United Kingdom and the major ports of Continental Europe than New York or other American ports. It is about 2,000 miles by water and rail from the heart of the Canadian wheat growing area, yet it is the world's largest export grain port. The harbour is open to navigation for about 8½ months a year, and yet it has grown to its present stature in competition with ports which operate on a year-round basis.

The port facilities are located on the St. Lawrence River along a 16 mile stretch of the east side of the Island of Montreal. This island is the site of the City of Montreal which is the largest city in Canada, with a population of 1,600,000 in its metropolitan area. The port is at the head of 35-ft. navigation and is approached by means of a well marked, easily navigated channel with a minimum width of 550-ft. at river bottom on the reaches and 800-ft. on the curves and a minimum depth of 35-ft. at extreme low water. A dredging project to increase the width to 800-ft. on the reaches and 1,500-ft. on the curves is well advanced.

The port is open to navigation from early in April to about mid December each year. Prior to the 1958 season of navigation the latest date of departure of an ocean-going ship was on December 21, 1953. This record was broken when 12 ocean ships, assisted by ice breakers, left Montreal for overseas destinations on January 14, 1959.

Montreal Harbour is above tidal range. In the upper harbour, where the rate of flow is increased due to a narrowing of the channel by several large islands, the effects of the current are nullified by a guard pier 7,000-ft. in length.

The Seaway, with a depth of 27-ft. of water, begins at Montreal. Prior to the opening of the Seaway, the interior of Canada and the United States were served by a 14-ft. canal system which also began at this port. Due to many factors, among which are its location at the downstream end of the Seaway, its large number of sailings, its extensive and modern port facilities, a large proportion of Montreal's port business consists of trans-shipment between inland water-way carriers and ocean ships.

History

The site of Montreal, where the Indian Village of Hochelaga once stood, was discovered by the great French adventurer Jacques Cartier in 1535, when exploring the St. Lawrence River in search of a westerly route to China.

Another famous explorer, Samuel de Champlain, visited the Montreal region in 1603 and again eight years later. He chose the site of the harbour and established the first trading post, which he named Place Royale. This trading post was used by Champlain and those who followed him as a base for the exploration of the Upper St. Lawrence and Great Lakes, the Richelieu River and Lake Champlain, the Ottawa River and other tributaries of the St. Lawrence.

The first successful attempt to establish a permanent settlement was made in 1642, when Paul de Chomedey, Sieur de Maisonneuve, and a party of settlers of the Company of Notre Dame de Montréal, arrived at Place Royale and renamed the settlement " Ville Marie de Montréal."

During the next two centuries trade with Europe expanded. Fur trading prospered and business ventures were launched which developed into sound industrial and commercial enterprises. Railroads and canals were built, immigration was encouraged, farms were hewn out of virgin stands of timber and the frontiers were gradually pushed back.

Montreal shared in the development of the country but the growth of the port was hampered by shallow water in the St. Lawrence River between Lake St. Peter and Montreal, where the limiting depth was 10½-ft. at low water. Difficulties were also encountered by sailing vessels in navigating the powerful St. Mary's Current in the harbour. Quebec was then the principal ocean port and goods were transported between Montreal and Quebec by canoe, by long boat and, later, by Durham boats, which were small barges with very large fore and aft sail and topsail.

With the advent of steam navigation it was apparent that the obstacles to development of Montreal as a port could be overcome. In 1822 the merchants of the City formed an association known as " The Committee of Trade," which later became the Board of Trade. This organisation pressed successfully for the dredging necessary to permit the early development of the port.

The first Harbour Trust Commissioners were appointed in 1830 by the Government of Canada. Two years later Montreal was incorporated as a municipality and was classed as a port of entry.

The commission type of administration was continued until 1936. In that year, by Act of Parliament, the National Harbours Board was set up, with jurisdiction over eight of the principal Canadian deep sea ports, including Montreal. This form of administration is still in effect, with the operation of each port carried out by a Port Manager and operating staff.

Facilities

The Port of Montreal is well equipped with the modern facilities necessary for efficient operation. These installations will be described briefly below.

Wharves and Piers

The harbour facilities include wharves and piers with a total berthing length of

approximately 12 miles, which provide berths for 131 vessels. Two-thirds of these have minimum depths of from 30 to 35-ft. at extreme low water level. With the exception of a length of 980-ft. of wharf, the remaining berths vary in depth between 25 and 29½-ft., and are thus capable of accommodating ocean ships.

Thirty-four of the berths are equipped with transit sheds.

There are special berths for loading and unloading grain, in addition to the 21 transit sheds which are equipped with conveyor galleries to permit grain loading. One berth is specially equipped to handle bulk raw sugar and a number of berths are designated for handling coal, ore and similar commodities. Oil, gasolene and other petroleum products are handled in bulk over wharves designed and equipped for that particular purpose. One wharf is reserved for handling cement and other bulk commodities. The remaining open berths are used for handling automobiles, steel, scrap, timber, machinery and other cargo items which do not require special handling equipment or protection from the elements.

Practically all berths are served by a terminal railway which is owned and operated by the Board. Water and electricity are also available at most berths.

Upper portion of Montreal Harbour.

Transit Sheds

Montreal Harbour's 34 transit sheds provide a total floor area of 2,700,000 sq. ft. Nineteen of the sheds are two storey structures, approximately 500-ft. long by 95-ft. wide. This type of shed is well adapted to the handling of imports and exports by ships in liner service. The usual procedure is to unload import goods to the upper floor while export cargo is accumulated on the lower floor. The disadvantages of this type of shed are mainly: (1) Additional handling charges are involved in import shipments which move by rail, due to the necessity of moving goods to the lower floor before loading on freight cars, and, (2) The dimensions and lifting capacity of the freight hoists limit the size of transport trucks which can be elevated to the second floor to pick up import cargo. Existing hoists have dimensions of 16-ft. by 30-ft. and a lifting capacity of 15 tons.

The single storey transit sheds vary somewhat in size but the dimensions, in general, are about 500-ft. by 120-ft. The more recently built sheds have no interior columns to interfere with cargo handling. A shed at present under construction will be 750-ft. by 150-ft.

All sheds are of fireproof construction and are equipped with standpipe fire protection systems.

Grain Elevator System

During the mid 1920's Montreal earned the title of the world's greatest grain export port. In 1928, 217 million bushels were received and 211 million bushels shipped, a turnover of 14 times the storage capacity during a shipping season of about 8 months. This included a heavy movement of American grain. In subsequent years the shipment of American grain through Montreal was drastically reduced, with the result that the 1928 record has not been repeated. Shipments vary from year to year due to fluctuations in the world demand for Canadian grain. For example, shipments in 1950 amounted to 85 million bushels. In 1952 this quantity was about doubled, with a volume of 165 million bushels. The quantity shipped in 1958 was 125 million bushels.

Montreal has 4 grain elevators with a total storage capacity of 16,762,000 bushels. This includes a storage addition of 1,600,000 bushels capacity, which is under construction and practically completed. The elevator system includes almost 4 miles of grain conveyor galleries which feed grain to 28 loading berths of which 21 are occupied by transit sheds, thus enabling liners to take on general cargo and grain without moving. With this network of conveyor galleries it is possible to load grain into 25 ships simultaneously.

In recent years approximately 80 per cent. of all grain received at Montreal has been delivered by ship from Upper St. Lawrence or Great Lakes ports. Eight unloading berths, equipped with a total of 14 marine legs (bucket conveyors on an arm which dips down into the hold of a ship), are available for unloading these ships. Three of these, equipped with high speed marine legs and pneumatic equipment for clean up purposes, are designed for the rapid unloading of " lake type " grain carriers which have a cargo capacity of about 700,000 bushels. The two marine legs at each berth have unloading capacities ranging from 36,000 bushels per hour per leg at one berth to 27,000 bushels per hour for each leg at the other two berths. The pneumatic clean-up equipment installed on each marine tower has a capacity of 10,000 bushels per hour. One of these berths is now in operation and the other two will be operating shortly.

The remaining five unloading berths are equipped to unload " canal type " vessels which have a cargo capacity of approximately 90,000 bushels.

Grain delivered to the elevator by rail is unloaded by means of car dumpers—heavy installations, each of which lifts a freight car loaded with about 2,000 bushels of grain, and empties it by tilting it in various directions. Five of these are available, each of which has a capacity of 6 carloads of grain per hour. A number of mechanical car shakers are also available, if required. With these facilities and equipment it is possible to receive and ship up to 2 million bushels of grain in a 13 hour day.

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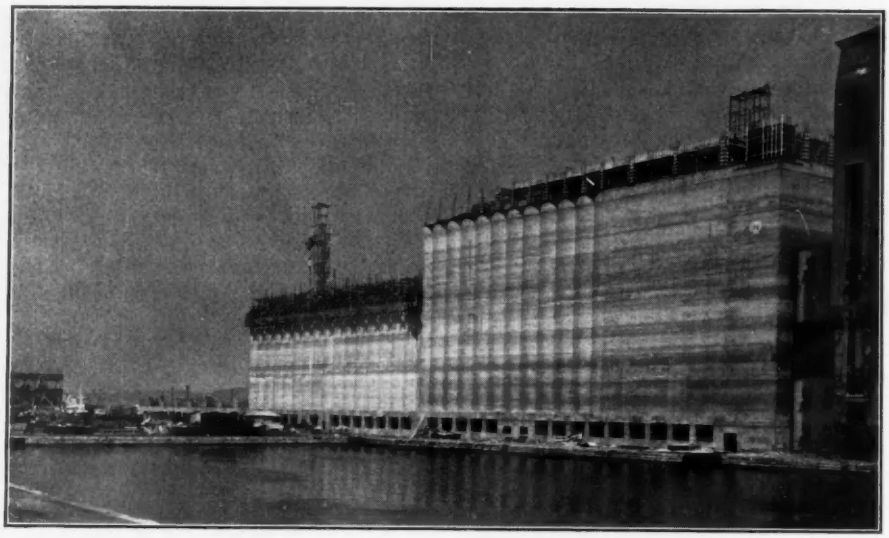

Grain elevator B.1 under construction at Montreal Harbour.

Railway Facilities

The National Harbours Board owns and operates a terminal railway 62 miles in length together with eight 100-ton, 660 h.p. diesel switching engines. This railway connects with the two principal Canadian railways, Canadian National Railways and the Canadian Pacific Railway Company, and serves practically all berths in the harbour. As many as 1,550 railway cars per day and 233,000 per year have been switched to and from berths. This service, which permits cargo to be brought to or picked up at shipside by rail carriers at almost all berths, increases the efficiency of the port and reduces the cost of shipping through Montreal.

Cold Storage Warehouse

The Board owns and operates a cold storage warehouse which, with a capacity of approximately 3 million cubic feet, is one of the largest in Canada. The warehouse is divided into three sections known as freezer, cooler and ordinary storage. It is also equipped with fast freezing equipment.

The warehouse was originally built to handle export goods but there is little business of that type at the present time and it is used mainly to help fill the cold storage requirements of local merchants.

Miscellaneous Facilities and Services

In addition to the main facilities described above, the Board owns a wide variety of auxiliary equipment necessary for efficient harbour operation. A Board owned and operated floating crane of 75 tons rated capacity is available for lifts anywhere in the harbour. This crane can handle up to 90 tons at limited outreach. For heavier lifts, there is a privately owned fixed crane with a capacity of 120 tons. The Board also owns two tugs, two floating derricks and a number of flat scows and dump scows which are used for maintenance dredging and for handling ships' ballast. Six locomotive cranes and one diesel caterpillar crane, each of 30 tons capacity, are also available.

An extensive electrical power transmission system has been built to deliver electricity to all parts of the harbour. A water distribution system also serves ships and facilities in all sections of the port.

In addition to the foregoing National Harbours Board facilities, there are available at Montreal a 25,000 ton capacity floating dry dock, graving docks and excellent ship repair facilities operated by private companies. Towboat services are also provided by a private company which maintains a fleet of tugs in service throughout the season of navigation.

Coal and oil bunkering are carried out efficiently by private interests which make deliveries direct to vessels at special coal and oil wharves. Oil can also be delivered by barge or tanker at any berth.

Operation

Approximately 17.8 million tons of waterborne cargo was handled in 1958. In 1956 the quantity handled was over 18.4 million tons, which is the present record for the port. Grain constituted the largest item, followed by petroleum, petroleum products and coal. Other commodities handled in large volume were raw sugar, steel, motor vehicles, gypsum, flour and other grain products, asbestos, phosphate rock, chrome ore, cement and scrap.

A total of about 6,000 ships carried cargo and passengers to Montreal in 1958, of which almost 2,700 were deep-sea vessels. The total number of passengers landed and embarked was in excess of 218,000.

Montreal is different from many large ports in that all piers and wharves, transit sheds, grain elevators and practically all other facilities and equipment are owned by one authority, in this case the National Harbours Board.

Approximately two-thirds of the transit sheds, with prior use of adjacent berths, are leased on a seasonal basis to shipping companies which operate regular liner services and have sufficient business to assure a high degree of utilisation of the sheds. The Board reserves the right to permit the use of such sheds by others when not needed by the seasonal lessee. The other sheds are retained for the general use of shippers and are leased on a daily "first come, first served" basis.

The coal, oil and cement wharves are leased on a long term basis to firms engaged in these businesses. These companies install, maintain and operate their handling equipment.

In line with general Canadian and American practice, the wharves are not equipped with cargo handling cranes. Ships' gear is used for loading and unloading cargo.

The loading and unloading of freight cars is carried out by the two trunk line railways. Their freight handlers move goods from cars to shed floor or wharf and vice versa. The movement of goods between the shed floor or wharf and the ship, including the stowage in or unloading from the ship is the responsibility of the shipping company. The work is done by stevedores in the employ of a private stevedoring company which, in turn, is under contract with the shipping company. Equipment such as tow motors, fork-lift trucks, hand trucks and small mobile cranes is owned by the stevedoring companies.

The grain elevators, cold storage warehouse, terminal railway, cranes and other equipment are all operated by National Harbours Board.

A large maintenance force operates under the direction of a competent engineering staff to ensure that all facilities are kept in top operating condition at all times. Most maintenance and repair work is done by National Harbours Board forces, but some large projects of a specialised nature are carried out by contract.

Construction Programme

The construction of new facilities has always played an important role in the activities at the port of Montreal. Since its earliest days, there has been a steady expansion of facilities to meet the needs of Canada's developing economy. During the last few years the tempo and scope of construction increased considerably with the introduction of an extensive programme of capital works. During the past three years $35,000,000 has been spent on this work, $27,000,000 is earmarked for expenditures in 1959 and later provision will be made for works to be completed at a subsequent

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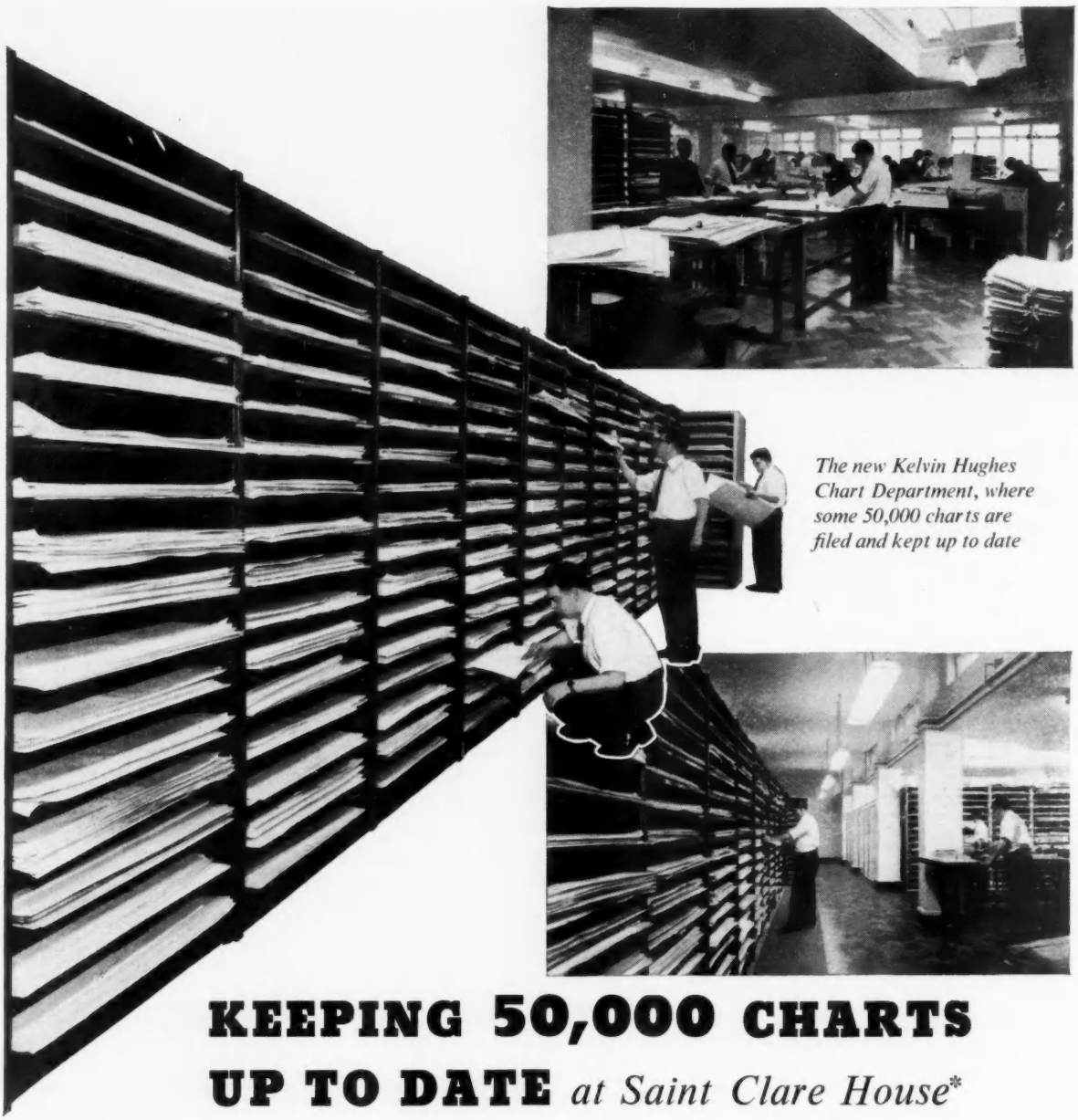

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date. A brief description of the construction programme is as follows:—

Wharves and Piers. During the past three years, work has progressed on 9 contracts for the construction of a total of 11,000 linear feet, or approximately 2 miles, of wharves. The construction of reinforced concrete cribs and cope-walls under this programme is about 90 per cent. completed and the remainder is expected to be finished this year. The placing of fill by hydraulic dredging and by truck is proceeding as rapidly as possible and should be practically completed by the end of 1959.

With the exception of a 700-ft. grain jetty, all wharves built under the present programme are marginal rather than finger type. The wharves consist of reinforced concrete cribs and a gravity type concrete cope-wall. The cribs and the entire area behind the cope-wall are filled with rock or other suitable fill materials. Cribs vary in size, depending upon location and specific needs. A typical crib, as shown in the attached plan, is 112-ft. long by 46-ft. wide and 42-ft. 7¾-in. high.

Sliding forms are used in crib construction. In some instances concrete is poured for the lower part of a crib, to a height of about 12-ft., on a launching platform at the water's edge. The crib is then permitted to slide into the water and construction is completed while it is afloat. Another system calls for construction of the lower section on a scow or floating platform, which is then sunk to permit the crib to float. The method more commonly used here entails construction of the lower part in a temporary dry-dock built of steel sheet piling. The dry-dock is then flooded, the crib is floated out and concrete is poured to the required crib height at a berth alongside.

The crib is then towed to the wharf site, where overburden has been dredged to a solid foundation and a crushed rock mattress has been placed to a thickness of 1-ft. or more and levelled. The crib is sunk to its final position by opening valves which permit it to fill with water. Rock or other approved fill material is then placed in it, following which construction of the cope-wall proceeds. Backfilling is carried out as quickly as possible by hydraulic dredging or by truck or a combination of both. Recent wharves of this type have cost approximately $1,400 per linear foot exclusive of backfill.

Transit Sheds. The transit sheds built at Montreal Harbour in recent years have been steel frame, clear span structures with a mill type wooden roof, a concrete floor slab with asphalt surface and corrugated aluminium or galvanised steel sheathing. Experience in the past has shown that aluminium is no more costly than galvanised steel and it is preferred since it eliminates maintenance painting.

The Empress of Britain entering Montreal Harbour.

The sheds are equipped with turnover doors with an overhead clearance of 16-ft. in every second 22-ft. bay on the water side and a combination of turnover and vertical lift doors in all bays on the land side. Rail lines are built on the land side of the sheds at an elevation such that shed floor and railway freight car floor are at the same level. The area between tracks is paved and trucks can also load or unload at this side of the shed.

The sheds are equipped with stand-pipe fire protection. Adequate office accommodation is provided with each shed.

The latest type shed of this type was built at a cost of about $7.00 per square foot of floor area.

During the past five years, nine new transit sheds and one shed extension have been added to the port's facilities, increasing the shed floor area by about 500,000 square feet.

Grain Elevator System. A heavy construction programme has been carried out to add to the port's grain storage facilities, to provide high speed unloading equipment, to construct additional fast loading berths and to make changes in various grain elevators and conveyors to increase their efficiency.

Construction of a 1.6 million bushel extension to Elevator B. is practically completed and will be in operation shortly. Plans are well advanced for a new elevator of 5.3 million bushels capacity. A contract has been awarded for the construction of the required wharves at the site of the proposed new elevator. When this work is completed, work on the elevator will begin.

Approximately 4,000 linear feet of grain conveyor galleries were built, to provide new grain loading berths and to make it possible to transfer grain unloaded at new Grain Jetty No. 1 to either Elevator No. 1 or Elevator No. 2.

The construction of one high speed unloading berth for lake type grain carriers has been completed and put in operation and the construction of two additional berths of this type is well advanced.

Work is practically completed on contracts for changes in three grain elevators which will increase the speed and efficiency of these elevators. The work included the installation of the latest type automatic scales, installation of higher capacity conveyors and removal of a wide range of equipment in the elevators.

A car dumper was installed at each of Elevators Nos. 1 and 2. Each dumper has an unloading capacity of 6 railway cars per hour or a total of approximately 12,000 bushels of grain per hour.

Dredging. A capital dredging programme costing about $10,000,000 is well advanced. A major item provided for the widening of the turning basin in the upper harbour to accommodate the lake type grain carriers. This basin has a depth of 35-ft. at extreme low water.

The remainder of the work consisted of dredging approach channels to six new wharves.

Bridge Decking Contract

The first contract for bridge decking to be placed outside the U.S.A. for a North American project has been obtained by Fisher & Ludlow Ltd. of Birmingham, one of the British Motor Corporation companies. The decking, which is now being manufactured, is for the new Prescott-Ogdensburg Bridge which links the New York to Ottawa Highway as part of the St. Lawrence Seaway project.

The contract, which is worth half a million dollars, is due for completion by September next, and deliveries are well in advance of site requirements.

XUM

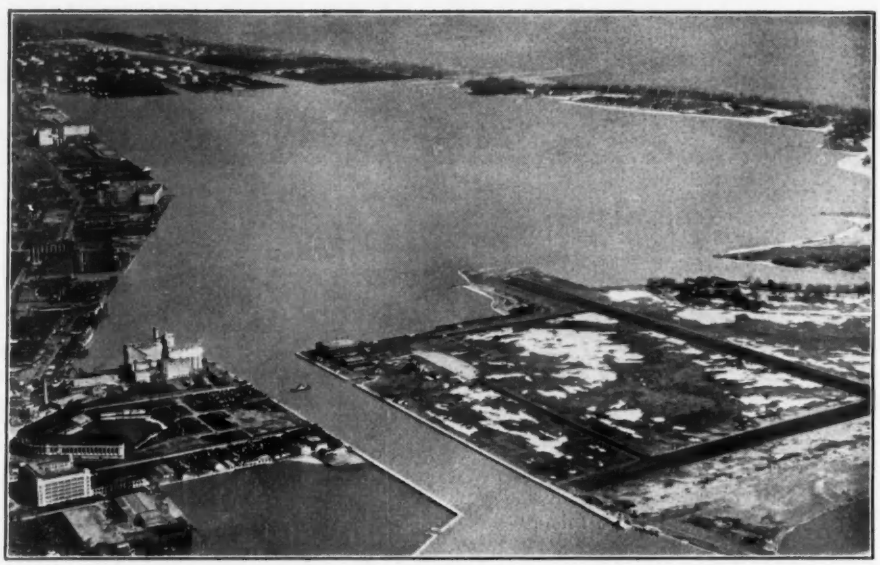
The Port of Toronto

By E. C. HOPKINS (Director, Trade Development Department)

Development of the Port

The Port of Toronto has played an important role in the development and growth, not only of the City itself but also of the Province of Ontario and indeed, the Dominion of Canada.

The harbour administration has passed through three distinct periods, the first being from 1793 to 1850 under control of the Provincial Government the second from 1850 to 1911 under divided ownership and control of a harbour commission, the city authorities, the railway companies and private individuals. The division of authority during this particular period brought about a chaotic condition in both shipping and harbour facilities. The third period commenced in 1911 and inaugurated the entire control of the port administration under commissioners appointed by provision of "The Toronto Harbour Commissioners' Act, 1911."



Aerial view of harbour—looking east showing Western channel in foreground, through which all ships pass when entering the port.

Under this Act, 5 commissioners were appointed — three by council to represent the City of the Toronto Board of Trade. Power was given to the new body to expropriate land to ensure the proper development of the Port and they were also given the right to issue bonds in order to secure finances for the work necessary to provide an up-to-date harbour. These bonds were guaranteed as to principal and interest by the City of Toronto and this fact brought about the majority appointment of the Commissioners by the City. This form of administration has been carried down through the years and is still in existence.

Surveys, plans, reports and estimates were prepared at once and approved, but actual construction work was delayed by the outbreak of World War I.

Immediately following the declaration of peace in 1918 all work was accelerated and has been carried on continuously since. This work covered every phase of waterfront development including the reclamation of land for park and recreational purposes. In this connection Toronto was the first city on the North American Continent to combine in its plan of harbour development, park and recreational features with harbour improvement and industrial and commercial development.

The outstanding feature of the early planning and development was the optimism shown by both the administration and its officers. Although the St. Lawrence Seaway has been discussed for many years and its ultimate approval remained in a state of doubt for many years to come, they had faith that it would one day become a reality. This faith was substantiated by the construction of piers for possible dredging to 30-ft. without endangering the construction of the foundations. This has saved the port millions of dollars in reconstruction and new construction works that have to be faced by some of the port authorities on the Great Lakes who unfortunately built for the day and not the future.

The harbour is equipped with facilities necessary for the rapid and economic discharge and loading of cargoes of all types. It is no uncommon sight to see self-unloading vessels discharging their coal cargo of 10,000 to 15,000 tons and clearing for another cargo in less than 10 hours after their arrival time. The waterborne trade of the port, which for more than half a century had practically remained at a standstill, has in recent years, by reason of the harbour improvements and the ever expanding market, increased rapidly and continuously. It has advanced from a total of 248,363 tons in 1921 to approximately 5,000,000 tons today, an increase of over twenty fold.

The factors contributing to this increase are the natural advantages of location, combined with the harbour improvements, all of which tre most necessary to a modern port, and may be enumerated as follows:

(a) ample accommodation for all classes of shipping ; (b) a local market of considerable importance assured by the fastest growing manufacturing centre on the Continent with a population of over 1½ million in the Metropolitan Area alone ; (c) a rich and prosperous hinterland, with the necessary facilities for economic and rapid collection and distribution by rail, water, highway and air.

Direct Overseas Trade

The movement of package goods by vessel has for many years placed the merchants and manufacturers of the area in the enviable position of being able to sell their goods for less than those that happen to be located some distance from a port. Cheaper rates on waterborne cargo, is, of course, the reason for this.

In the early days of Toronto, the long overland travel by horse and wagon was costly, and the opening of navigation each year was eagerly awaited and appropriately celebrated. To-day the arrival of the first overseas vessel into the harbour after the freeing of the St. Lawrence of ice, is still celebrated, perhaps not so robustly as in former years, but the captain of the vessel is presented with a dispatch case to mark the occasion.

When it is considered that only five vessels and a number of tramps of foreign registry were engaged in the through trade from the Continent to the Great Lakes area in the year 1936, the growth of this phase of shipping has been astounding. Those five ships of the liner type making regular calls, have increased to over 144 in 1958 and are owned or chartered by 28 shipping lines. They fly flags of France, Germany, Great Britain, Sweden, Norway, Holland, as well as others.

During 1958 there were 1,317 entrances and clearances of overseas registered ships, an increase of 271 over the previous year. They brought directly to the Toronto area imports from 78 ports in 23 countries, while exports from the area were sent to 69 ports in 27 countries.

The vessels entering the port in 1958 were

of necessity the smaller type of ocean-going vessel, limited by the existing canal system to 252-ft. in length. Even then they are compelled to lighten their cargo at down river ports in order to have a 14-ft. 6-in. draft for navigation through the shallow channels. This, of course, meant that a vessel which normally operated with a 27-ft. draft and was capable of carrying some 2,800 tons of cargo was only able to transport 1,400 tons of cargo to the Great Lakes Basin. The balance of the cargo destined for ports inland had to be transshipped, thus increasing the ultimate costs of transportation.

The increase in the number of lines engaged in this trade accelerated upon the announcement that the Seaway was to be an actual fact. The desire of the various lines to become established early in the race for new business was evident and as a result of the increased demand for vessels suitable for the canal draft, the charter price increased sharply and actually brought about a scarcity of this type of vessel for tramp sailings.

The situation has become so acute that scrap metal dealers in the Toronto area with large tonnages for export have been unable to secure bottoms and have been forced to ship by rail to Montreal where numerous tramps of the large tonnage capacity are able to handle the cargo. This, of course, adds to the cost.

The opening of the Seaway means a new pattern of shipping and new ships themselves. It has also entailed considerable growing pains for the port of Toronto. Chief among these was the problem of handling ocean freight through lake freight terminals. Dockside aprons which had been designed and were entirely adequate for handling goods from side hatch loading ships, proved too narrow for the top hatch operations. The overhanging roof on the terminal which was provided to protect cargo from inclement weather, instead of being a boon for ocean cargo, became a handicap with ships' tackle continually fouling and becoming a source of annoyance to winch operators.

The time taken in the clearance of goods through customs proved irritating to consignees who were accustomed to having their shipments cleared through other ports and were unaccustomed to the delays that are taken for granted in long established seaports.

The building of the new Marine Terminal No. 11 at the foot of Yonge Street, designed specifically for overseas vessels, eliminated these two problems. Wide dockside aprons of 35-ft. together with a flush front on the building itself made the speedy loading and unloading of ships a possibility.

The customs' problem was overcome by the construction of an examination room on the premises to which goods could be moved instead of having them transferred to the city customs' warehouse. This is believed to be the first installation of this kind in a marine terminal in Canada and has achieved considerable time saving.

Most of the cargo is discharged by means of the ship's gear. Occasionally, however, when articles of cargo are beyond the capacity of the ship's winches it is necessary to engage the new marine derrick of The Toronto Harbour Commisioners to complete a "heavy lift." This equipment, installed in 1958, is capable of handling lifts up to 50 short tons. The previous heavy lift equipment with a capacity of 25 short tons has been retained as auxiliary lift equipment.

Development of Port Facilities

The construction as outlined in the first part of this article, was in the main directed to facilities for lake trade such as the movement of coal, petroleum products, grain, sand, gravel, cement, and other bulk cargo. The central portion of the harbour itself was set aside for package freight terminals. With the opening of the Seaway the facilities are being increased to provide additional accommodation. Marine Freight Terminal No. 11 described above, was the first step in this programme. The second step has been the completion of a new 26-acre dock site situated between Jarvis Street and Parliament Street on the waterfront.

Extending the length of five city blocks, the dock was created by dump fill, much of which was taken from city construction projects including the rapid transit tunnel. The retaining wall, 3,300 lineal feet in length was completed by the Federal Government at a cost of almost $1\frac{1}{2}$ million, and considerable dredging was carried out. This dock estate will be used in the development of further transit terminals for large ocean vessels. The first terminal, No. 15, was commissioned for service in the spring of 1958. Although different in design to No. 11, it still provides approximately 100,000 square feet of floor space. At the official opening in May, 1958 an announcement was made concerning the construction of No. 17 terminal on the same area. This has now been completed and opened for use. In addition, the entire area was graded and dockside aprons installed for handling outside cargo. This additional space will form steps three and four in the expansion work. This 26-acre area has been named the "Queen Elizabeth Docks" by permission of her Majesty, Queen Elizabeth II.

Step five comprises the dredging to provide the required draft for the larger vessels. The Federal Government placed contracts for this work and by the opening of navigation in 1959, it has been completed to the extent that all overseas terminals now have 27-ft. of water alongside. The sixth step will probably result from the concentration of certain heavy industries in the area brought about by transporation, economic and industrial changes, and will involve further development works. For instance, the coal and oil industries are at present in a fluctuating state which may

Aerial view of Terminal No. 15, Port of Toronto.

eventually lead to the utilization of some of this dock property for other purposes.

It is anticipated that these various steps will provide sufficient berthing space to handle any increased traffic in the forseeable future.

The Commission is not content with this, however, and their Planning Department is at present working on a further programme which it is expected will cover a 25-year period. When finished, this will create an additional 12 miles of berthage together with approximately 1,400 acres of industrial and dock property.

Trade Development

It has long been an established fact, that a two-way trade is necessary to maintain a nation in world markets. This holds equally true in the shipping business. Ships that operate only one way with full cargo and return with empty holds, force upwards the cost of transportation on the goods so carried. It is therefore important that this two-way trade of nations be carried to the shipping level. Indications to date are that the import shipments are increasing substantially, but the export trade is lagging behind, although showing improvement in the last few years.

With this in mind, the Commissioners in 1955 established a new department to encourage the movement of merchandise, both inward and outward, through the port. Known as the Trade Development Department, one of its functions is to have a representative call upon all importers and exporters, not only in the Metropolitan Toronto Area, but in all the municipalities in the hinterland where industrial clients are possible sources of cargo. It is by means of these contacts that assistance is offered to the consignees and shippers in solving many of their problems—problems that pertain to regulations, rates and transportation lines.

In addition to the increased trade that results from these efforts, information is obtained from the various firms influencing the demand for construction of docks, transit terminals, and other port facilities.

One other phase of the port business that should develop as a result of the Seaway is transhipment of cargo. On the larger vessels, the costs per day run as high as $2,000 to $3,000. For this type of ship to sail further up the lakes with but a small tonnage would be uneconomical. The answer is transshipment of this tonnage whether be lake carrier, rail or truck and it is indicated that the growth of this business may occur, as it has previously in Montreal.

It has already been said that the harbour administration has passed through three distinct periods. It is now in its fourth—its Seaway Period — and from all indications, this could be the most beneficial of them all.

The Port of Hamilton

By C. W. MORGAN, B.Sc., P.Eng. (General Manager)

By authority of The Hamilton Harbour Commissioners Act, passed on April 1st, 1912, the Port of Hamilton is administered by three Commissioners, one appointed by the City of Hamilton and two by the Federal Government. First visited by La-Salle in 1669, the Port is located at the head (west end) of Lake Ontario, and is conveniently situated to serve the requirements of all of south-west Ontario and the Niagara Peninsula.

Shipments routed through Hamilton to and from overseas ports avoid the extra time and expense required for passage through the Welland Canal to and from ports located farther inland. Fast overnight rail and truck service to the dockside in the Port of Hamilton, together with the rapidly increasing frequency of scheduled overseas sailing serve to expedite shipments via the Seaway.

The City of Hamilton, fifth largest in Canada and easily the most highly industrialised area for its size in the country, is located on the south side of the harbour. Half of the nation's primary steel production is located on the waterfront, with many other large and diversified industries in the vicinity.

Although by far the larger part of the annual cargo volume through the Port consists of ore, coal and other materials connected with steel production, the overseas trade has been steadily increasing since it began with one shipping line in 1948. In 1958, entries and clearance of overseas vessels alone rose to 700, an increase of nearly 30% over the 1957 figure.

Tonnage handled through Hamilton in recent years has exceeded that of any other Canadian Great Lakes port, and Montreal is the only Canadian port on the new St. Lawrence Seaway showing greater tonnage. In 1957, tonnage handled through the Port of Hamilton rose to a record figure exceeding 8 million tons, and nearly 3,500 entries and clearances were recorded.

The reason for this high position among Seaway ports was supplied by The Honourable George Hees, Minister of Transport, when officiating at the opening of the Port's new $3,700,000 Wellington Street Wharf extension and general cargo terminal on August 20th, 1958. Pointing out that Hamilton Harbour is considered to be the finest land-locked harbour on the Great Lakes, he said " The fact that so many industries have established themselves in Hamilton, many of them adjacent to the waterfront, is indicative of the importance of this city as an industrial and and distributing centre and still more so of the important part that water transportation has played in its development." Referring to the tonnage figures, Mr. Hees continued " These figures, which place Hamilton among the leading ports of Canada, not only reflect the industrial growth of the city, but indicate the wisdom and foresight of the Harbour Commissioners over the years in planning for the future."

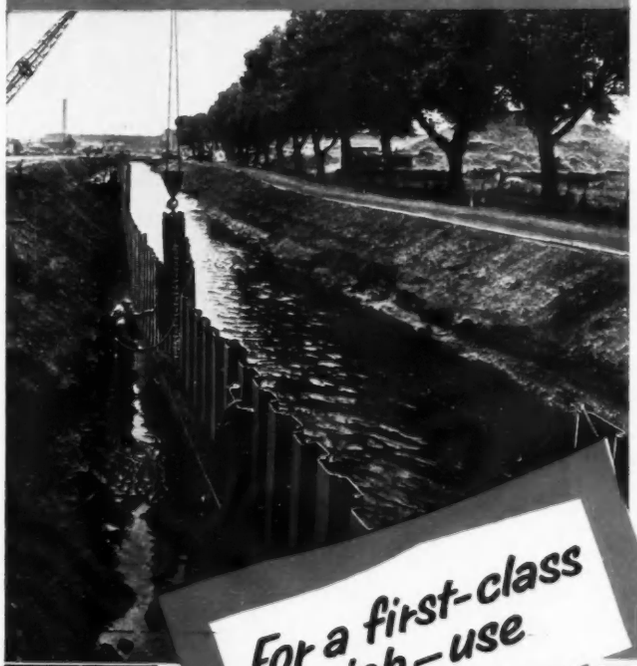
Commissioners' Development Plans

The current port development programme is now well advanced. This was initiated in 1955 when the entrance, Burlington Channel, was deepened to 28-ft. to provide Seaway draft in the harbour. Work on the Wellington Street Wharf extension was commenced later in the same year.

This wharf extension costing some 2½ million dollars and providing 2,625 linear feet of additional berthing space and 10 acres of increased wharf space was completed during 1958. Together with the Commissioners' Marine Freight Terminal No. 8, erected at a further cost of $1,200,000. This building, which has a covered cargo area of 200-ft. wide by 600-ft. long, brought the total of sprinkler-protected, fireproof storage space available at the Wellington Street Terminal to 192,000 square feet. A two-storey, air-conditioned office building and a Customs and Terminal staff wing, both completely fire protected, extend the width of the inshore end of the new Terminal. Office space is rented to agents of shipping lines and to stevedoring companies.

New Bulk Materials Wharf. Half a mile east at Wentworth and Ship Streets, construction of Terminal Wharf No. 3, or Ship Street Wharf, to provide additional wharf space for the handling and storage of bulk materials, was commenced in mid-summer, 1957. Space on this new wharf, having an area of nearly 17 acres and 2,380 linear feet

Larssen piling in use in the Pymmes Brook Improvement Scheme for the Lee Conservancy Catchment Board. Engineer: N. Medrington, A.M.I.C.E., M.I.W.E. Contractors: Howard Farrow Ltd.



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XUM

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In ports throughout the world, conventional methods of loading and discharging ships are being superseded by palletisation and industrial trucking. This has resulted in more tonnage per gang-hour; in less breakages; in quicker turn-round and bigger pay packets for dockers.

Handling eggs . . .

A new scheme embodying the use of pallets and Yale trucks is already showing economies to the North of Scotland, Orkney and Shetland Shipping Company.

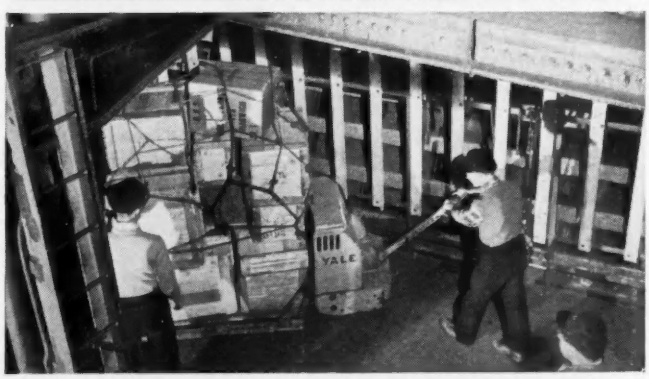
By the end of this year over 80 million eggs from Orkney and Shetland will be handled on Leith quays by Yale Series 51 trucks; stowed in ships' holds by Yale Hydraulic hand lift trucks. Tonnage handled has risen from 7 to 20 tons per gang-hour, breakages have been considerably reduced, and dockers' earnings have gone up.

Yale Series 51 electric trucks are available in capacities from 3,000 lbs. to 10,000 lbs.

General cargoes . . .

Recent re-timings of shipping services between Harwich and the Hook of Holland cut available cargo handling time at Harwich by a third. The Dutch shipping company, Stoomvaart Maatschappij 'Zeeland', adopted trucks and pallets to ensure tonnages handled were not similarly reduced. Here, British Transport Commission men use Yale Worksaver pallet trucks to move cargo to the centre of the hatch for craning overboard.

Yale Worksavers are available in platform and pallet models (2 or 3 tons), Fork Lift (1,500, 2,000, 2,500, 3,000 lbs.), Tractor (700 lbs. draw-bar pull).



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Stowing crated cars on an uneven surface formed by irregular packs of tinplate became simpler, less laborious when Yale Hydraulic hand trucks were brought in to do the job.

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of berthage, is now available for lease. Full seaway depth is provided at all faces, and wharfside rail facilities are under consideration. Estimated cost of this project is $2,000,000.

The Strathearne Avenue Project. In the hitherto undeveloped south-east end of the harbour, the Strathearne Avenue project has also been underway since early in 1957. Dredging by the Canadian Department of Public Works is nearing completion to provide a new Ship Channel and Turning Basin together with Strathearne Avenue Slip, the latter extending over 2,300-ft. in length to the south shore. Seaway depth is being provided throughout and the material dredged is being used to reclaim wharf space aggregating 23 acres on both sides of the slip.

Five overseas ships discharging and loading general cargo at Hamilton Harbour Commissioners' Wellington Street Terminal.

Berthing space totalling one mile in length is under construction at Strathearne Avenue, and the total cost of the project has been estimated at over $5,000,000, including dredging; 1,500-ft. of berthage at the outer end of the west side was completed in 1958 and is available for lease. Construction of the remaining length on that side is being undertaken in 1959. The provsion of wharfside rail facilities is contemplated.

Dredged material from the Ship Channel and Turning Basin is also being used to reclaim an additional 42 acres on the Hamilton Beach side to provide future wharf space to be available under lease adjacent to the new Skyway.

Improved Harbour Entrance. The most spectacular event to take place in the harbour in 1958 was the opening of the new Skyway Bridge across Burlington Channel. This $19,000,000 structure arching high above the harbour entrance provides a most impressive approach to the port. Built by the Ontario Department of Highways, it provides a four-lane link in the well-known Queen Elizabeth Way connecting Hamilton with the Niagara frontier and with Toronto.

A second new bridge across Burlington Channel, a vertical lift bridge to carry both rail and local vehicular and pedestrian traffic, was commenced in 1958. This structure, being built by the Department of Public Works at an estimated cost of over $5,000,000, will replace the existing bascule highway bridge and railway swing bridge, making possible the removal of a mid-channel support pier. This will provide full-width navigation in the channel and improved passage for the largest vessels using the new Seaway.

Full-width navigation through the entrance will eliminate berthing at the North Pier. In order to provide alternative wharf space for the Commissioners' tenants, the construction of a new and larger wharf, set back from the channel at the inner end of the North Pier, is being undertaken during 1959. This structure will have an area of approximately 15 acres, will provide 1,700 linear feet of berthage, and will be used principally for the movement and storage of bulk materials. Space not required by present tenants will be available for lease to others.

Depths in the harbour are generally well in excess of Seaway standards, except in the slips which have, heretobefore averaged 22-ft. in depth. However, a programme of dredging undertaken by the Department of Public Works to provide Seaway draft to Commissioned-owned wharves is now nearing completion.

Other Improvements

Publicly-owned wharf, terminal and bridge construction together with dredging and land reclamation undertaken since 1955 in the Port of Hamilton and planned for completion by 1961 will total nearly $40,000,000, as indicated by the foregoing account. However, this represents only part of the transformation taking place in the port.

Hamilton industry also has embarked on large scale plans to provide greatly improved and extended wharf structures equipped with the most modern materials handling facilities. Both the Steel Company of Canada and Dominion Foundries Limited, which together produce on Hamilton's waterfront half the steel made in Canada, have spent and are spending many millions of dollars on wharf extensions and facilities, and International Harvester of Canada Limited have recently completed a million dollar wharf reconstruction programme.

At the municipal level, the City of Hamilton's council has already indicated approval of an ambitious programme of highway interchanges at the north-east and north-west ends of the City. These will link major city thoroughfares with provincial highways and expressways.

Hamilton lies at the heart of what is called the Golden Horseshoe — an area stretching from beyond Toronto around to the eastern end of the Niagara Peninsula, in which is centred Canada's wealthiest industries, real estate, and road and rail networks. Three major railway lines lead to the Port's docks and a network of highways aid quick transhipments and fast turnround of shipping.

The Port of Hamilton made early and far-reaching preparations for the St. Lawrence Seaway advent, and stands ready to deal efficiently with what it confidently anticipates will be a steady increase in business through the Port. Having provided the most modern terminal facilities for general cargo and having several Seaway depth wharf projects now becoming available for lease the Commissioners also have an efficient Trade Development Department which is eager to answer enquiries concerning the shipment of goods or materials through the port.

The Long Sault Canal Engineering Works

Construction of Eisenhower and Grass River Locks

By Col. LOREN W. OLMSTEAD
(District Engineer, Buffalo, U.S. Army Corps of Engineers)

On May 13th, 1954, President Eisenhower affixed his signature to the establishment of the St. Lawrence Seaway Development Corporation. This agency was given the responsibility of constructing the U.S. portion of the Seaway Project consisting of two locks, extensive dredging and other works in the International Rapids Section, between Ogdensburg and Massena, New York. The Corporation appointed the Corps of Engineers as their design and construction agents.

The excavation for the two locks—one in marine clay and the other in glacial till —was difficult and arduous. The Government specifications required that the foundations of each lock rest on bed rock. The problem was to remove millions of cubic

yards of this material before actual lock construction commenced. The nature of the material was such that to excavate to the required depth, it was necessary to develop an area having a saucer-type appearance. Excavations were made on the basis of, for every 1-ft. dug vertically, a corresponding 2 to 10-ft. of material was removed horizontally.

The glacial till overburden which had to be removed in excavating the Dwight D. Eisenhower Lock, when compacted had the density of concrete. It consisted of fine gravel and boulders embedded in dense clay. This required the heaviest types of equipment for loosening and removal and, in some instances, had to be blasted prior to excavation. In addition to the excavation for the two locks, a canal 10 miles long and 450-ft. wide—the Long Sault Canal, was dug through both types of material to carry ships round the power development. Over 39 million cubic yards of earth were removed.

Aerial view of the first ships to enter Dwight D. Eisenhower Lock, July 1958.

Many methods were employed to excavate the Long Sault Canal. One contractor found it feasible to drill and blast in some of the area. Usually he would drill and blast an area from 100 to 200-ft. wide and 300 or 400-ft. long. The entire area was fired simultaneously in order to lift and loosen the material. Still another method of excavating material was by means of a hydraulic dredge, although this had its drawbacks when obstacles were encountered.

Although the excavation of material formed the primary operation in building the Long Sault Canal, it is the two lock structures, located therein, that provide the means for vessels to by-pass power structures. Both the Dwight D. Eisenhower and Grass River Locks have the same dimensions—800-ft. long, 80-ft. wide with 30-ft. depth over the sills. These measurements conform to other locks under construction on the St. Lawrence River. Of the two locks perhaps the Eisenhower presents the more interesting features. It is this lock that contains two components that are not made a part of the Grass River Lock—a vertical lift gate and a highway tunnel through the lock.

The vertical lift gate located at the upper end of the lock will serve only as an emergency gate. This emergency gate when lowered is recessed into the floor of the lock which will permit traffic to proceed over it. In the event of a vessel ramming the upper lock gates this emergency device would promptly be put into operation. With the upper lock gates damaged and the lift gate raised into position the intermediate pool and the lower lock would not be flooded, thereby preventing a loss of power development during this crisis.

The second interesting feature of the Eisenhower Lock is the highway tunnel that will pass through the lock sill. In anticipation of an unusually high vehicular and seaway traffic a tunnel was designed to permit highway traffic to pass under the canal without interrupting Seaway traffic. The two-lane highway passes through the upper sill and is carried through barrel sections outside to the extent of the fill adjacent to the lock. Every conceivable modern installation will be incorporated in the tunnel—tile walls and ceiling, exhaust fans, proper lighting fixtures, etc.

Both locks are a concrete gravity type structure resting on solid rock. Each lock will raise or lower a vessel about 45-ft. They will have usable dimensions of 768-ft. in length and 75-ft. in width and will be provided with guide walls above and below the lock on the north side of the channel to permit vessels to tie-up at the guard wall before entering the lock. The gates are protected by a fender or arm carrying a 3½-in. steel cable that should prevent a vessel, out of control, from damaging any of the gates. Approximately ½ million cubic yards of concrete has been used in each lock.

The concrete was made at the site. Rock quarried at Helena, New York, approximately 10 miles away was processed through crushers for sizes 6-in. down to ¼-in. material. The fines from this process were in turn processed through a sand plant where they were crushed to sand sizes. Broken into sizes the ingredients were hauled to the construction site where the reclaiming of material from the stock piles to the concrete plant was accomplished by means of a tunnel under the stock piles. All sizes except the finest in sand were reclaimed at one time. En route to the concrete plant the material was washed and finally rescreened into sizes and deposited in bins. The material was automatically batched and weighed prior to mixing. Finally, it was mixed for a predetermined length of time and dumped into a wet batch hopper before being deposited into 4 yard buckets for haul to the construction site.

The story of the Long Sault Canal would be incomplete if the system of dykes to the south of the canal were not mentioned. This system of dykes has been built to contain the pool that will be raised upon completion of all power structures. Due to the topography to the north of the St. Lawrence River, it is not generally necessary to construct these earthen retaining walls.

However, on the opposite or south side, it is quite a different story. Here dykes generally running parallel to the river and the navigation channel are essential to prevent flooding the lowlands and to protect industrial and residential property. An agreement was made with the power authorities to utilise excavated material for both power and navigation interests. This has proved to be very beneficial to all concerned.

Up to this point, navigation has been the principal concern but the Seaway is only a

portion of the St. Lawrence Project. In addition to the navigation aspect, the development of power features an equally important role. The entire St. Lawrence Project will cost approximately one thousand million dollars. It is being constructed under four different agencies in the two specific phases mentioned. The more expensive or power phase is under the direction of the Power Authority of the State of New York representing the United States interests. Co-operating with the Power Authority is the Hydro Electric Power Commission of Ontario representing Canada. The two power entities have under construction the Barnhart Island or St. Lawrence Power Dam located at the foot of Barnhart Island; the Long Sault Dam; the Iroquois Dam and dredging between Ogdensburg and St. Regis Island in the International Rapids Section. The Canadian authority is also constructing the Iroquois Lock and Dam. The entire outlay for both power entities will exceed 660 million.

Any article on the St. Lawrence Project would be imperfect without, at least, a brief description of the power structures. In describing a power project there is no such thing as one structure or dam being more important than any other. Each serves as an integral part of the whole programme. Construction of the St. Lawrence Power Dam is a joint venture by the New York Power Authority and Ontario's Hydro Commission. In such a venture one would normally think that the contractors would erect their respective portions in a uniform manner. But this is not the case—contractors from South of the border elected to build their half full length erecting the structure uniformly — the Canadian contractors elected to complete their half by completing one end leaving the opposite end untouched. To the casual observer it would appear that the U.S. contractors have progressed further than their counterpart, but actually this is not true. Since the power dam is bisected by the International Boundary, each country will share in the development of power equally. When completed this 32 unit generating station will develop nearly 2¼ million horsepower from a maximum power head of 87-ft. This two-in-one structure forms an integrated concrete dam about 3,200-ft. long which spans the channel in a straight line at right angles to the direction of water flow.

The second major feature of the power project is the Long Sault Dam. This concrete gravity type dam located at the head of Barnhart Island will rise 145-ft. above the foundations. This, together with the Power Dam, will serve to raise the St. Lawrence about 90-ft. above natural conditions. The third dam at Iroquois, Ontario, will serve to control the flow of water in the St. Lawrence and out of Lake Ontario. When completed the dam will be a buttressed gravity concrete structure with gate-controlled sluiceways. The lowland on the United States side will be closed by rolled earth fill wing dams and on the Canadian end of the dam will connect with the new Seaway canal lock at Iroquois Point.

Not to be minimised is the construction of a High Level Bridge to span the south channel of the St. Lawrence replacing the existing Roosevelt crossing. The replacement was necessary in order that Seaway Traffic can proceed uninterrupted upstream and downstream in the new channel. One of the principal features that made this phase a challenge to the contractor was the tight schedule from which he had to work. The locks had to be constructed by early 1959

Removal of Roosevelt Bridge

By Col. LOREN W. OLMSTEAD, District Engineer (Buffalo)
and R. E. BURNS, Assistant Project Engineer
(U.S. Army, Corps of Engineers)

On May 6th, 1958, an important milestone was reached in construction of the U.S. portion of the St. Lawrence Seaway in that the first span of the existing Roosevelt Bridge was floated out as a part of a very tight work schedule preparatory to commencement of navigation on July 4th, 1958. The float-out of the north and centre spans and the preparation for dismantling the existing Roosevelt Bridge required the solution of some novel design and construction problems.

The bridge superstructure removal is part of the contract to the American Bridge Division, United States Steel Corporation, for construction of the superstructure of the new International High Level Bridge that will span the South Cornwall Channel of the St. Lawrence River approximately 1,200-ft. upstream from the old bridge site. The contract required the north and centre spans to be removed from the bridge piers on or before May 15th, 1958, so that work on another contract for removal of the substructure could commence on May 16th, 1958. The old bridge did not have sufficient clearance for navigation purposes.

History of the Old Bridge

The old Roosevelt Bridge was constructed as a railroad bridge for the New York and Ottawa Railroad. Work on the bridge started in 1897 and was completed in October, 1900. In 1934, a timber deck was placed so that it could serve as a dual purpose railroad and highway bridge. The bridge consisted of three arched truss spans, 368-ft. in length with a 62-ft. girder approach span at each end. The three main spans were supported on stone piers, one on the United States mainland, two in the river, and one or Cornwall Island, Canada.

During the erection of the superstructure of the old bridge, a serious accident occurred. The north and centre spans of the bridge had been completed and erection of the south span was proceeding when on September 6th, 1898, the south river pier, supporting the south and centre spans, settled and crumbled towards the U.S. shore dropping the centre and south spans into the river. Fourteen men were killed and several were injured.

Most of the south span was salvaged and an attempt was made the same year to raise the centre span by floating it to the mainland. The operation was unsuccessful, although the span was moved downstream a short distance where it remained until October, 1957, when it was removed from the river by Merritt-Chapman & Scott Corporation as part of a saeway dredging contract. Prior to completion of channel improvement, current in the South Cornwall Channel attains velocities up to 13-ft. per second, thereby rendering operations involving marine plant as extremely difficult and hazardous.

Following the accident, borings indicated that the pneumatic caisson substructure which supported the pier was found to be on a thin layer of hard pan underlain by a 15 to 20-ft. layer of soft clay. This thin layer was insufficient to carry the load and failure resulted. The faulty substructures were subsequently replaced by sinking caissons through the soft clay deposits to hard material with satisfactory bearing characteristics.

Bridge Preparatory Work

A stress analysis of the trusses in their float-out position resulted in some interesting findings. In the float-out position, the trusses were supported on the lower chord at the fourth panel point from each end, in place of their normal simple support at the ends. This induced cantilever action reversed the major stress in most of the primary members, requiring the trusses to be reinforced prior to their float-out. Preliminary work consisted of:

(a) The upper chords of the existing spans were designed as compression members. In the float-out position, the upper chord would be subject to tension. An analysis showed that the chord members were sufficient to carry

this tensile stress, but that the joint connections would not. A circular tie plate 15-in. x $\frac{7}{8}$-in. welded all around was installed on each side of the joints to get an effective continuation of the top chord.

(b) The existing bottom chords were tension members consisting of either six or eight 8-in. x $1\frac{1}{4}$-in. parallel bars with pin connections at the joints. In the float-out position, these groups of bars would not carry the induced compression load. To build up these bars into effective compression members, angles 3-in. x 3-in. x $\frac{3}{8}$-in. were welded across the bars in a lacing pattern.

(c) The third phase of the reinforcement was concerned with the diagonal members. The existing tension diagonals, two 8-in. x 1—7/16-in. bars, would not take the compressive stresses induced when the spans were lifted. The compressive values in these members were neutralised by substituting tension members within the same panel between opposite panel points. These installed tension members were $\frac{7}{8}$-in. wire rope falls reaved to seven parts.

(d) In addition to the above-described reinforcing of the spans two stiffleg derricks with 75-ft. booms were erected on the top of the south span, between the second and third upper chord joints from the ends. They were used for the assembly of the floating plant and the dismantling of the north and centre spans. A third stiffleg derrick with a 65-ft. boom was erected on the north end of the south span for driving the piling and erection of temporary pile bent 2.

(e) The plan of operation was to float out the north span first and set it upon temporary pile bents adjacent to the existing piers upstream of the south span, and then float out the centre span prior to any dismantling. Each temporary pile bent consisted of eight "M" piles which, in turn, supported falsework built up to the same elevation as the existing masonry piers. Large steel beams were placed from the pile bents to the masonry piers. It was upon these two large beams that the north span would be landed prior to dismantling.

View showing the north span being moved. In foreground derrick being erected for placing high-level bridge tower.

Floating Plant

One of the major items in preparation for float-out was the assembly of the floating plant. The plant consisted primarily of a falsework truss 117-ft. long weighing 217 tons, that was erected on two barges 38-ft. x 123-ft. x 10-ft. 6-in. The truss was fabricated specially for this operation and field erected at the site. The barges were set 60-ft. apart and held by a compression member at each end and diagonal wire rope tension members at the ends and middle.

The jacking system consisted of four 500-ton hydraulic jacks with 25° runout, two on each barge. The jacks on each barge were set between an upper and a lower jacking beam. Either beam could be moved vertically, between two columnar sections at each end, and fixed in position by 3-in. diameter pins through the columns. The jacks on each barge could be worked jointly or separately by water supplied by an air compressor-operated piston displacement pump.

The falsework truss was supported on each barge by a transverse beam resting on the upper jacking beams. Consequently, during the jacking operation, it was the entire falsework truss that was jacked. The plant was designed so that the location of the jacks was directly under the designated pickup points on the bridge spans (the fourth panel points from the ends).

On each barge was installed a 3-drum hoist with diesel engine. On each drum was 2,600-ft. of $\frac{7}{8}$-in. wire rope. It was by means of these cables affixed to the anchorage system that the floating plant was moved across the river.

Anchorage System

The anchorage system for the float-out operation was of paramount importance in view of the swift river current. It consisted of three sets of anchors in the river and one deadman on the U.S. mainland. The anchor locations varied from 700 to 1,000-ft. upstream from the old bridge.

Each set of anchors consisted of two 20-ton reinforced concrete blocks, 9-ft. x 10-ft. 6-in. x 3-ft., which were constructed on site with pickup eyes and other steel embedded in the concrete. The effective weight of each block under water was 23,770 lbs. In order to increase the holding capacity of the anchors, a 24-in. steel toe was embedded in the downstream edge and four 9-in. long steel stubs protruded from the bottom 2-ft. from the rear edge. This type of anchor has a holding capacity of 100,000 lbs. in fine sand.

The anchors of a set were connected by 150-ft. of $\frac{7}{8}$-in. wire rope through an 11-in. sheave which tended to give an even distribution of load to each anchor block. This sheave was connected by 200-ft. of wire rope to a second sheave through which passed the haul lines from the barges. Each set of anchors was equipped with four buoys, one to each anchor block and one on each of the sheaves.

The Float-Out

On the afternoon of May 5th, 1958, the floating plant was taken from the erection site just downstream of the south span, moved across the river, and floated into position under the north span. Once under the north span, it took nearly ten hours to manoeuvre the float into its exect jacking position with 6-in. clearance between the falsework and bridge trusses. To secure the barge in this position, it was necessary to keep all haul lines taut, including the one to the deadman on the south river bank, thereby completely shutting off all navigation on the river.

As a result of prior planning, two United States Coast Guard boats were on 24-hour per day duty policing the river traffic in the vicinity of the bridge.

Crews reported at 5 o'clock on the morning of May 6th. By 6 a.m. the jacking was

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under way and in a few minutes the falsework truss was in contact with the bearing plates on the span. The first 36-in. of jacking was taken up by depression of the barges as they took the load of the span. At 11 a.m., after another 16-in. of jacking to compensate for the sag at the end of the spans, the north span lifted clear of its piers.

The span was floated upstream about 200-ft. and then laterally across the river. By 3 p.m. the span was in position upstream of the temporary pile bents adjacent to the south span piers. At this point, the stern haul lines were fastened to the masonry piers on each side. Then the span was manoeuvred into its exact position over the temporary supports. Four hours later, at 7 p.m., the float had been secured in position and the jack-down of the span commenced. It took approximately one hour to jack-down and another hour to secure the span on the temporary supports. By 9 p.m. the north span float-out was completed.

On May 8th, the centre span was floated out in much the same manner as the north span. However, there were two major changes in this operation. The centre span had to be floated downstream to reach its dismantling position alongside the south span. This downstream movement necessitated the switching of anchor lines from one side of piers to the other by a small tugboat. The second change was that the centre span did not have to be jacked down on temporary supports since the dismantling was performed with the spans supported by the floating falsework.

Dismantling of the old centre span commenced May 9th with cranes working from each end of the span cutting the steel with acetylene torches. The stiffleg derricks on top of the south span were used to hold the members during the cutting and for loading the steel into railroad cars which were situated on the south span. The dismantling of this span was completed in one week. The floating falsework was then moved under the old north span. The span was jacked clear of its temporary supports and dismantling proceeded as it did for the centre span.

Prior to dismantling of the old south span, the contractor mounted a crawler crane (80-ft. beam and 30-ft. jib) on a barge. With this, the stiffleg derricks were removed from the south span. The span was jacked from its piers and dismantling, using the barge-mounted crane, proceeded.

Substructure Removal

Separate from the superstructure removal, removal of the substructure commenced on schedule on May 16 with the drilling of the first holes preparatory to blasting. The masonry piers were removed to within 5-ft. of the water level by a series of small demolition charges. From this position, the piers were drilled through their footings and demolition charges — consisting of 2,200 lbs. of TNT in the north river pier, and 2,700 lbs. in the south river pier—demolished the remaining portions of the piers. A 9 c.y. dipper dredge was used to remove the debris from the river bottom.

General Information

Preliminary work on this project started February 10th, 1958, when a crew of 18 men started reinforcement of the existing spans. The reinforcement was completed on April 24th, 1958. Prior to the closing of the bridge on April 2nd, traffic over the narrow bridge had to be maintained while work was going on. It took approximately 3 weeks to erect the floating plant. The removal of the superstructure was completed when the last steel of the old bridge's south span was picked off the floating falsework on June 11th, 1958.

The Port of Cleveland, Ohio

By FRANK L. GORMAN, M.A.S.C.E.
(Chief Engineer)

The Port of Cleveland, the progressive metropolis of Ohio, has been serving the industrial heart of America as an efficient international port for over one hundred years. Its growth and resultant prestige has largely stemmed from handling the large volume of raw materials and bulk cargoes emanating from the development of the upper Great Lakes. By supplying these materials for the use of industry, this section of America, has become one of the greatest in the modern industrial field.

Cleveland Harbour is the result of two separate developments—the Inner Harbour or the Cuyahoga River section, which serves a large proportion of Cleveland's industrial production, and the Outer Harbour or Lakefront Area of midtown Cleveland, which is designed for the receipt and distribution of freight from any world port.

The facilities of the Inner Harbour, with one exception, are privately owned and operated by various industries. They are equipped to handle in great volume such commodities as iron ore, furnace stone, sulphur, cement, grain, pig iron, semi and finished iron and steel, petroleum, petroleum products, chemicals and rubber. All transportation is handled direct to or from ship to railroad, to truck or to warehouse under all conditions.

The facilities of the Outer Harbour are protected by a breakwater 27,350-ft. long, with entrances from the east and from the north, directly opposite the mouth of the Cuyahoga River, the entrance to the Inner Harbour, or Industrial section.

Completion of the Outer Harbour, which is still in course of construction, will provide efficient berthing space for ships up to 27-ft. draft with overall lengths of up to 600-ft.

The existing facilities at Cleveland for the receipt or shipment of cargoes of the kind which have been handled for many years are adequate. However, if, with the opening of the Seaway, trade increases and different commodities are offered for which existing facilities are unsuited, terminal operators whether they are stevedoring companies or in industry have given assurance that the facilities will be provided.

The Port of Cleveland now has in operation terminal facilities in excess of those required to accommodate existing operations. There are three dock and warehouse units in the port regularly engaged in terminal service for domestic export and import freight and one in regular operation which does not handle any of the overseas export-import trade. Shipments of ordinary size and weight present no problems, and one crane is in operation, with a capacity of 100 tons at a reasonable radius, while there are others with a lesser capacity which have a greater radius of operation.

The Cleveland Stevedore Company at its Main Avenue Riverfront Inner Harbour Terminal owns a dock with 1,200-ft. of berthing space, 25,000 square feet of covered storage area, and a Baltimore and Ohio railroad siding with access to other lines serving Cleveland through reciprocal shipping. Also, as an added facility, this terminal is readily accessible to highway transportation over loading platforms capable of accommodating twenty-five motor trucks by means of tractor cranes. The same company has three other piers, 1,000-ft., 550-ft. and 450-ft. in length, available for handling bulk cargo. A transit shed is to be erected on one of the piers and will be used in the general cargo trade when business warrants. All thre piers have railway and highway connections with direct access to the new waterfront.

The Lederer Terminal, just west of East 9th Street on the Lakefront, has a finger

XUM

type pier 720-ft. long and 300-ft. wide which now provides 1,740-ft. of berthing space for ships. The two transit sheds serve an enclosed area of 78,000 square feet for cargo handling and storage. This terminal is equipped with mechanical handling devices including heavy lifts and light cargo handling cranes. It has a New York Central Railroad siding with reciprocal switching arrangements with other lines and has direct access to all highways and city streets.

The National Terminals Corporation operates a dock and warehouse at Main Avenue on the Cuyahoga River for the Baltimore and Ohio Railroad which owns the property. The dock has 500-ft. of berthing space and 30,000 square feet of covered floor area with cranes and mechanical equipment for cargo handling and storage; it has a Baltimore and Ohio Railroad siding with easy access to highway transportation.

The Nicholson Cleveland Terminal Company owns and operates a wharf and warehouse at East 55th Street on the lakefront. This has 574-ft. of berthing space and a four-storey transit shed and warehouse with an aggregate area of 200,000 square feet. This terminal is equipped to handle general commodities with mechanical handling devices but so far, has not undertaken to serve overseas traffic confining its operations to inter-lake business, mainly newspaper and new automobiles. It has a large open storage area, New York Central Railroad connection, and easy access to streets andh ighways.

It should be emphasised that three of the facilities described are already serving as terminals for overseas export-import commodities. They can accommodate ten of the small freighters now engaged in the Lakes-to-Ocean trade and by including the Nicholson Terminal, an additional two such vessels could be accommodated. Should more freight be offered, the Cleveland Port has what may be termed stand-by docks which can readily be made available with very little repair or new construction.

In preparation for increased use of the port after the opening of the St. Lawrence Seaway, a bond issue of $8,000,000.00 was authorised in November, 1955. Of this amount, $6,000,000.00 was for waterfront projects and the remaining $2,000,000.00 for the Lakefront Airport improvement.

The City administration itself owns a dock, initially intended for passenger service, and engineering work on the extension of this pier has now been completed.

In addition to the existing facilities, when the Outer Harbour has been completed, the port will be able to berth four additional ships up to 600-ft. long with carrying capacities up to 12,000 tons. The service of tugs

Cleveland Harbour viewed from the east.

is unnecessary due to the convenient open harbour and the ample length and width of the berthing slips.

Refrigeration service is available on some of the vessels serving the port and in addition to the operation of scheduled lines, charter service of tramp ships can be secured through vessel brokers.

Five major railroads give the City of Cleveland an excellent grade of service to and from points in its natural territory. These, together with the more than 130 common carriers which have terminal facilities in the area complete the co-operation between industry and transportation. Export freight can be loaded at any major point in Ohio or within any reasonable distances in western Pennsylvania, West Virginia, or eastern Kentucky and be delivered at dock side in Cleveland within twenty-four hours after custom and clearance movements are completed. The time in the reverse direction is equally fast.

The port construction will, when in operation, provide adequate facilities to give complete service to any vessel traversing the St. Lawrence Seaway.

The Port of Detroit

The Port of Detroit extends along the Detroit River for about 18 miles and includes in .ddition to Detroit, the industrial suburbs ot River Rouge, Ecorse, Wyandotte and Trenton. The lower course of the Rouge River, a tributary stream, also provides frontage accessible to large vessels. At present all terminal facilities in the port area are privately owned and operated.

The port has required little additional work in its present harbour area in order to accommodate ocean-going vessels, as the Detroit River has a natural depth of between 29 to 51-ft. However, the Amherstburg Channel approach from Lake Erie and the St. Clair River approach from Lake Huron are being improved to a depth of 27½-ft. This work is under the direction of the U.S. Corps of Engineers and is part of the Federal Government's connecting channels project.

The commerce of the port has shown a continual increase in post war years and in 1957 reached 27.6 million tons. The bulk of this traffic is the receipt of coal, iron ore and limestone. Shipments are relatively low, normally about 1½ million tons per annum. It is expected that with the operation of the Seaway, Detroit will attract more shipping to the port. It is significant that by water the port is nearer to a number of northen European ports than either New York or Baltimore. In past years, most general products destined for overseas from

Detroit industries passed by rail to East and Gulf Coast ports, but now it will be possible to ship them via the Seaway.

There are 113 piers, wharves and docks on the Detroit River, of which 83 are in Detroit, 3 in River Rouge, 6 in Ecorse, 12 in Wyandotte, 3 in Riverview and 6 in Trenton. There are also 42 terminals on the Rouge River, 23 in Detroit, 13 in River Rouge and 6 in Dearborn. These bulk terminals handle almost 90% of the port's traffic.

Terminal Facilities

The two principal general cargo installations at the Port are the Detroit Harbour Terminals and the Detroit Marine Terminals. The Nicholson Terminal and a subsidiary, East Detroit Stevedoring Company, largely handle steel and bulk products. The Great Lakes Engineering Works specialises in the transshipment of liquid products and the loading and unloading of heavy-lift cargo. All are privately owned and operated and available for public use.

Detroit Harbour Terminals. All types of general cargo are handled at this terminal, most of the traffic consisting of overseas import-export commerce carried by foreign vessels. Facilities include 500,000 square feet of dry storage, 1,750,000 cubic feet of cold storage in a modern seven-storey building and 5 acres of open area, as well as two transit sheds with a combined area of over 37,000 square feet. The wharf is of concrete construction 1,131-ft. long with depth alongside of 22 to 24-ft., low water.

This property is served by the Union Belt Railway of Detroit. Mechanical handling equipment includes one 55-ton gantry crane with a 70-ft. boom, two 30-ton locomotive cranes, three 10-ton tractor crawler cranes, heavy and light fork lifts and one 200-ft. gravity conveyor.

Detroit Marine Terminal. The present depth of navigation is 21-ft. Of the 2,100-ft. frontage on the River Rouge, 715-ft. have been reinforced and improved as a quay-type wharf. The area behind the river frontage consists of 38 acres of flat and relatively low ground but this is in the process of being raised. The terminal is equipped with a small quonset shed of approximately 8,000 square feet which is used as a transit shed. There is a larger warehouse building 141-ft. from the face of the quay which can be used for limited transit shed storage if necessary.

The terminal can handle two small vessels or one large vessel at its concrete bulkhead and is equipped with gantry, crawler and mobile cranes, diesel and steam locomotives, heavy and light-duty fork lifts, magnets, buckets and pallets.

Nicholson Terminal and Dock is used for the receipt and shipment of iron, steel, coal and scrap bunkering, and for above-water repairs on vessels.

The pier is built on reclaimed land and has frontages of 486-ft. on the Detroit River, 750-ft. on the downstream slip, and 2,199-ft. on the upstream slip. Water depth varies from 28 to 10-ft. The property has 28 acres of open storage area and is served by the New York Central Railroad.

East Detroit Stevedoring Company. This terminal is located on a slip jutting into the Detroit River. The principal commodities handled are pig and scrap iron and steel, and the open storage area comprises 1,500,000 square feet adjoining the dock.

The equipment consists of a heavy-duty bulldozer to move commodities about the yard, and a 35-ton diesel shunting locomotive to manœuvre freight cars. Also, a heavy-duty truck and railway track scale is available for weighing purposes. This open storage area has 7,000-ft. of railway track connected with, and located on, the Detroit Terminal Railroad, with complete terminal facilities.

The berth consists of 1,400-ft. of apron area adjacent to the slip, which has a depth of 21-ft. To transfer cargo off and on vessels, there is an 18-ton capacity Browning gantry crane, and a Browning diesel locomotive crane of 40-ton lifting capacity.

The Great Lakes Engineering Works is primarily a shipbuilding, repair and outfitting terminal. On the Detroit River, at the face of one of its open piers, there is a shear leg crane with lift capacity of 90 tons, at which any vessel may lay alongside on request. This installation has 22-ft. of water to accommodate large carriers and the crane, with its 36-ft. reach from the edge of the quay, is sufficient to handle practically all types of heavy-lift shipments.

One other special service rendered by the terminal is the transshipment of liquid tallow from tank truck or tank cars to the deep tanks of the ocean vessels. This is accomplished at the heavy-lift berth. Transfer of liquids for export is through hoses and the necessary pressure provided by pumps furnished by the shipper. On imports, the ships use their own pumps. The terminal has indicated its ability to handle Seaway vessels with deep tanks and/or tankers.

The Port of Chicago

By Col. J. B. W. Corey Jr. (District Engineer, Chicago, U.S. Army Corps of Engineers).

Introductory

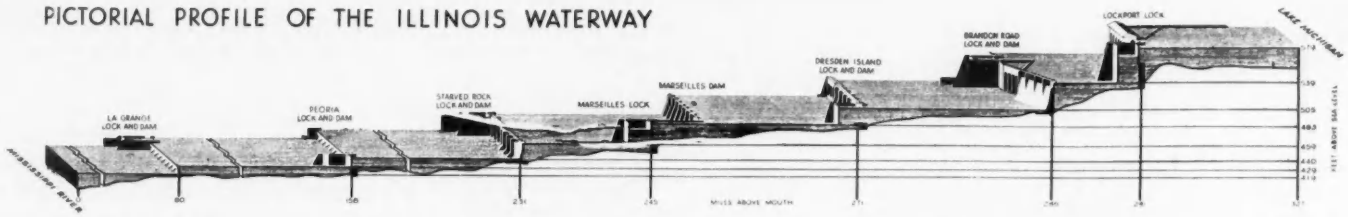
Early explorers who visited the site of Chicago almost 300 years ago recognised the potentialities of the unlimited water facilities and the rich resources of the surrounding area. Unique among the inland ports of North America, Chicago is the only place where the two great inland waterways of the Continent, the Great Lakes and the Lakes-to-Gulf waterways, meet.

As the most recent glaciers retreated, some 20,000 years ago, ice-scoured basins filled to become the ancestors of the Great Lakes. What geologists call Lake Chicago first covered the southern portion of the area now occupied by Lake Michigan and, in addition, most of the area of present Chicago. Until the lower northern outlet of this basin connecting with the other lakes and the St. Lawrence outlet developed after further retreat of the glacial ice, drainage was southwestward across the low divide at Chicago, to the Mississippi River and thence to the Gulf of Mexico. This great flow cut two depressions or sags in the divide down to bedrock ; one southwestward from the present site of downtown Chicago, and the other, known as the Calumet-Sag, westward from South Chicago. Thus nature set the stage for the later development of the Lakes-to-Gulf waterways. Upon further recession of the glacier, the northern outlet opened, and with an accompanying lowering of the lake level, the lake waters were forced by the bedrock floor of the Chicago outlet to abandon the two former channels through the divide. This divide now separates the Great Lakes and the Mississippi Valley drainage basins. The Indians followed smaller streams in the old depressions draining both ways from the divide, and very early the site of Chicago became an important portage between the two waterways. The opening of the Illinois and Michigan Canal in 1848 removed the land barrier in one of the sags and, for the first time, lake shipping and inland shipping met in the Chicago River.

Present Development

The Port of Chicago, situated in the northeastern part of the State of Illinois on Lake Michigan, includes Chicago Harbour and Calumet Harbour and their contributary waterways extending inland. Other harbours at the southern end of Lake Michigan included within Chicago Metropolitan

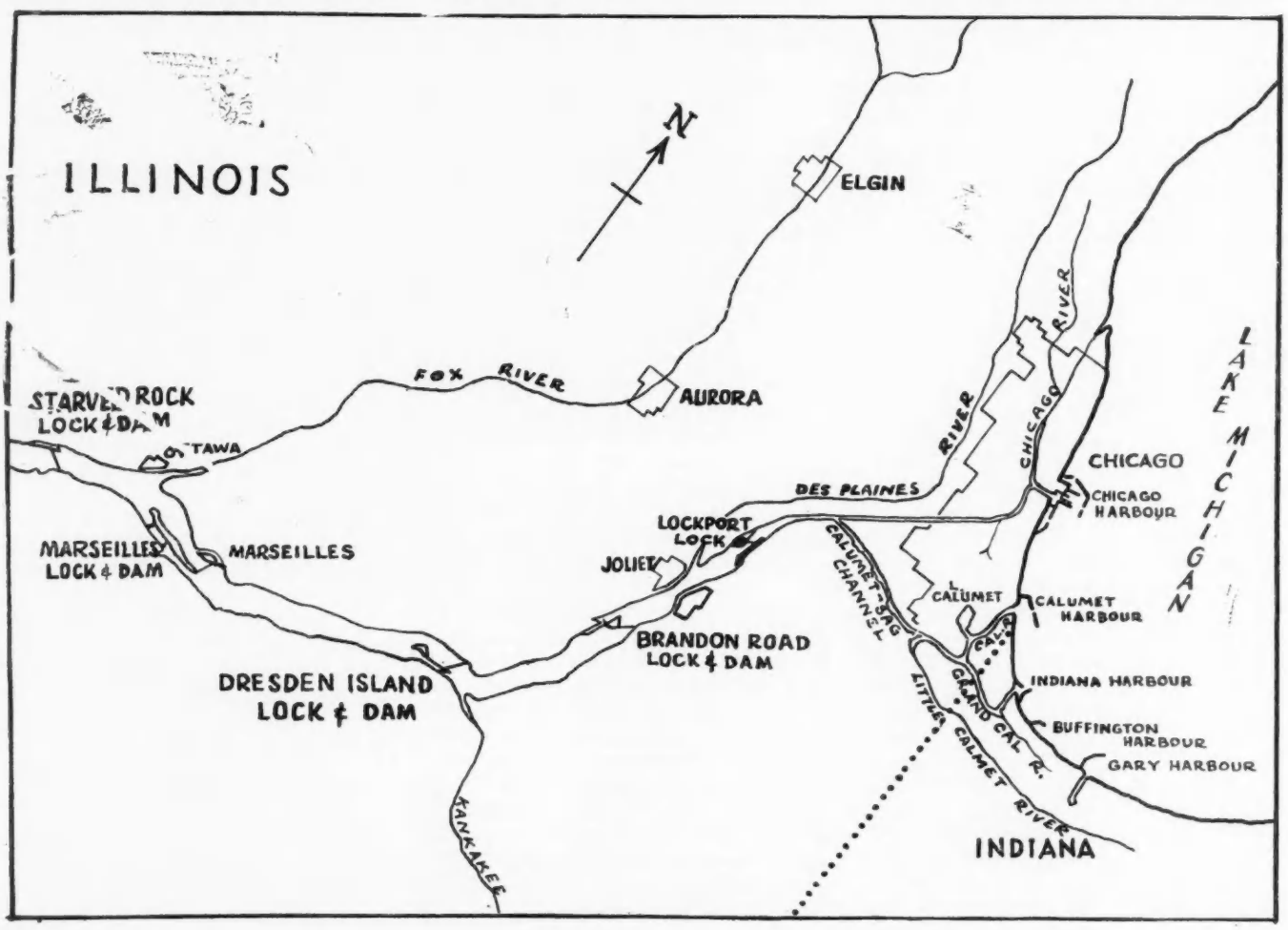
PICTORIAL PROFILE OF THE ILLINOIS WATERWAY



Area Ports, are the Indian, Buffington and Gary Harbours, all in the State of Indiana. The latter two harbours are privately owned.

Chicago Harbour is located at the mouth of the Chicago River, about 22 miles from the southerly end of Lake Michigan. The harbour has been under improvement by the Federal Government since 1833. The improvements by the United States have comprised the formation of inner and outer basins protected by breakwaters on the lake front north and south of the Chicago River. The breakwaters provide a harbour of refuge and also protect municipal piers of the City of Chicago on the lake front just north of the river entrance. The Federal improvement has also included dredging to a depth of 21-ft. below low water datum in the north section of the inner harbour basin and in the river entrance channel through the outer harbour. The authorised Federal navigation improvements at Chicago Harbour have been completed. From the lake, the outer harbour basin is open from the south and has approaches through the breakwater on the north and east. At the mouth of the Chicago River, controlling works were constructed by the Metropolitan Sanitary District of Greater Chicago in 1940 in order to control the river level at an elevation lower than that of the lake except in times of excessive storm run-off. A navigation lock is part of the controlling works. The north section of the inner harbour basin has the same level as the Chicago River and is accessible only by way of the controlling works lock.

The Chicago River extends westerly from the entrance for about 1½ miles and then diverges into a North and a South Branch. These branches, their forks, canals, and connecting slips are all included in the port area. The North Branch extends in a northwesterly direction through the City of Chicago. The South Branch extends southwesterly and divides into the West and South Forks; the South Fork is a dead-end stream about 1.7 miles in length; the West Fork connects with the Chicago Sanitary and Ship Canal, constructed about 1900 by the Metropolitan Sanitary District of Greater Chicago, which forms the present-day link to the Illinois Waterway-Mississippi River system. The Chicago River and its North and South Branches have been extensively improved by the United States,



but the present Federal project is limited to maintaining a depth of 21-ft. below a hydraulic grade line in the main river and for a distance of about 2¼ miles in the North Branch to North Avenue, including the North Branch Canal and the North Branch turning basin; thence a channel about 3½ miles long and 9-ft. deep to Addison Street; also a depth of 9-ft. in the South Branch and the West Fork as part of the Illinois Waterway. Essentially all of the authorised navigation improvements in the Chicago River and its branches have been completed.

Calumet Harbour is located at the mouth of the Calumet River, about 12 miles southerly from Chicago Harbour. The improvement of the harbour by the United States has comprised construction of an outer breakwater and of parallel piers at the river mouth, and dredging to a depth of 26-ft. below low water datum in the outer harbour and in the entrance channel. The breakwater affords protection to the river entrance and to the outer harbour, which is an important harbour of refuge for vessels during storm periods. The Calumet River extends southerly and westerly through the City for about 8 miles, and flows away from the lake except at times of heavy rains, floods, or sudden fluctuations of the lake level. Lake Calumet connects with the river about 5½ miles from its mouth. The Calumet River connects with the Little Calumet River at its confluence with the Grand Calumet River, and the improved Little Calumet River is connected to the Calumet-Sag Channel which in turn, at a total distance of 30 miles, joins the Chicago Sanitary and Ship Canal. This junction is about 23 miles from Lake Michigan at Chicago Harbour via river and canal.

Thus the Chicago and Calumet Rivers and their connecting waterways form a complete circuit for shallow-draft navigation, with the lakeward reaches of the Chicago and Calumet rivers affording depths for deep-draft navigation. The navigation projects for improvement in the Calumet River by the United States provide for a minimum width of 200-ft. and for a minimum depth of 21-ft. below low water datum from the harbour to, and including a channel into, Lake Calumet; thence as a part of the Illinois Waterway the channel has a width of 300-ft. and a nominal depth of 9-ft.

Currents

There are no perceptible tides on Lake Michigan, but the level of the lake is subject to continuous fluctuations of small magnitude over very short periods of time, commonly known as "seiches," which are caused by changes in atmospheric conditions. Ordinarily, these fluctuations do not exceed 2 to 6-in. in magnitude, but occasionally changes as great as 3-ft. or more occur at Chicago in periods of less than half and hour. At times the level of the lake is affected by winds of sufficient velocity to drive the surface water forward in greater volume than that carried by the lower return currents, thus raising the elevation on the lee shore and lowering it on the weather shore. At Chicago, strong winds have caused changes in still water level as great as 3 or 4-ft. above or below the prevailing mean stage, depending upon the wind direction.

Transfer dock and elevators at southern end of Lake Calumet at the head of deep-draft navigation of Calumet River.

Recent Development—Lake Calumet

Until recently, Lake Calumet was a shallow body of water in south-eastern Chicago, and connected to the Calumet River by a natural inlet. In the earliest history of the Calumet Region, the desirability of an inland harbour was readily perceived. In 1921, the Illinois General Assembly authorised the City of Chicago to construct a deep water harbour in Lake Calumet, and the City prepared an official plan for development of Lake Calumet. In 1937 the Federal Government dredged to a depth of 21-ft. a channel into Lake Calumet, on the basis that the City would construct a lake-rail-barge-truck terminal in Lake Calumet to meet the anticipated needs of navigation. In 1951, the Illinois General Assembly created the Chicago Regional Port District, and subsequent enabling legislation empowered the Port District to borrow money to acquire, construct, operate and maintain terminal and port facilities.

The first phase of the present Lake Calumet development involved an expenditure of 24 million dollars which was financed by sale of revenue bonds. Two grain elevators each with 6,500,000-bushel capacity were constructed in an area close to the general cargo terminal but yet apart from interference by land transport in and out of the harbour. Each elevator can load up to 120,000 bushels of grain an hour into lake and ocean vessels. Other basic faciilties constructed include three non-combustible transit sheds with a total area of 317,000 square feet, a dry storage back-up warehouse with an area of 200,000 square feet, and a 110-ton floating crane with a 45-ft. radius; this is the largest crane on the Great Lakes. Adequate rail and truck facilities have been provided. A second phase of the development, which at present is in the financing stage, will provide a second slip, two new transit sheds, another grain elevator, another back-up warehouse, and a cold store. A tank farm and bulk cargo handling dock are also being considered for development on the east side of the lake. The long-range development of Lake Calumet contemplates a harbour with a central anchorage basin; slips will radiate from the basin providing about 15 miles of berthing space.

Navy Pier

Constructed by the City of Chicago in 1914, Navy Pier is located in downtown Chicago. Designed primarily as a passenger and package freight terminal, the pier is about 3,000-ft. long and 292-ft. wide. At one time it was the principal terminal for lake steamers in the passenger and package freight business. Since the disappearance of this trade, the pier has been utilised for purposes other than maritime. However, the City of Chicago recently commenced construction to improve it to accommodate ocean-going vessels, and the south side is now being widened to provide a modern four-berth general cargo terminal.

Great Lakes ore carriers at docks lining the Indiana Harbour Canal in Indiana.

Calumet-Sag Channel

Constructed about 40 years ago by the Metropolitan Sanitary District of Greater Chicago, the Calumet-Sag Channel, about 16 miles in length, linked the waters of the Calumet, Little Calumet and Grand Calumet Rivers with the Chicago Sanitary and Ship Canal near Lockport and made possible the reversal of the flow in the Calumet River. A navigation lock 350-ft. x 50-ft. and controlling works to regulate the diversion of Calumet River waters was constructed at Blue Island at its easterly end in 1921. The Calumet-Sag Channel originally had a least depth of about 20-ft. and a minimum width of about 60-ft., and has been used increasingly for navigation. The channel is crossed by numerous bridges which, due to inadequate vertical and horizontal clearances, are obstructive to navigation. The Calumet-Sag Channel became a Federal waterway in 1930 by act of Congress. In 1946, Congress authorised additional improvements to provide for a minimum channel width of 225-ft. and a depth of 9-ft. for barge traffic. The plan provides for a new navigation lock and controlling works on the Calumet River to replace the old Blue Island lock. Dimensions of the new lock are 110-ft. in width and 1,000-ft. in length, adequate for a tow of 8 barges, each 35-ft. x 195-ft., and a towboat; depth over the sill is 16.5-ft. All obstructive highway and railway bridges across the Calumet-Sag Channel are being replaced to provide generally 225-ft. horizontal clearance and 25-ft. vertical clearance. Much of the work is now under construction, and it is anticipated that all work will be completed by about 1964.

Future Development

In anticipation of the completion of the St. Lawrence Seaway, Congress authorised a comprehensive survey of Great Lakes Harbours with a view towards future improvements. Insofar as the Chicago Metropolitan Area Ports are concerned, interim reports have been completed pertaining to Calumet Harbour and to Indiana Harbour. The Chief of Engineers, Corps of Engineers, U.S. Army has recommended that Calumet Harbour and Indiana Harbour be improved to minimum depths of 27-ft. below low water datum. Additional reports will consider the feasibility of providing 27-ft. navigable depths in Calumet River to Lake Calumet, in the Indiana Harbour Canal, and in Chicago Harbour.

Other Docking Facilities

In addition to the Lake Calumet development and Navy Pier, there are numerous other terminals in Chicago and Calumet Harbours. General cargo terminals are located on Chicago River, Calumet River, and Lake Calumet (in addition to the Chicago Regional Port District development).

The general cargo terminal on the Chicago River is located in the main entrance channel, just inside the navigation lock. The wharf can accommodate three ocean-going vessels, and has 153,000 square feet of transit shed and about 7,000 square feet of open storage area. Adequate rail facilities are provided, and additional berthing space can be made available at the bulkhead of an adjoining facility. Ocean and lake vessel cargo is handled by ship's tackle.

General cargo is received and shipped at a dock terminal located on the first turning basin inside the entrance to the Calumet River. The main channel and turning basin sides of the dock provide a total of 1,070-ft. of berthing space. Two transit sheds have a total of 27,000 square feet of storage space. An adjoining open storage area contains 175,000 square feet. Rail facilities are provided on the dock apron. A travelling bridge crane along the basin side of the dock is used to unload and load cargo vessels.

A general cargo wharf is also located at the entrance to Lake Calumet. This wharf has a 1,100-ft. bulkhead along Lake Calumet with a 20-ft. depth of water alongside. Transit shed area totals 44,000 square feet and about 16 acres of open storage are available.

There are 10 grain terminals along the waterfront within Chicago (exclusive of the Lake Calumet elevators), of which 3 are on the South Branch of Chicago River and 7 are on the Calumet River. The total storage capacity is about 41 million bushels.

Other docking facilities within Chicago and Calumet Harbour are in private use for the adjacent industries, such as iron and steel manufacture, coal transfer, and newsprint. Wharves on Indiana Harbour serve mainly the steel mills and oil refineries. Buffington and Gary Harbours are privately owned, and docking facilities are used for receipt of bulk commodities used in cement manufacture and the iron and steel industry, respectively, and for shipment of finished products.

Symposium on Icebreaker Design

Recently the Society of Naval Architects and Marine Engineers, New York, organised a symposium devoted to technical problems concerning the design of icebreakers. Six papers were presented, the first by Mr. L. W. Ferris, who dealt with the proportions and form of ice-breakers; Mr. J. Gordon German discussed the special features incorporated in the design of icebreakers, and the problems encountered in the construction stage, and Constructor Captain F. W. Matthews, of the Royal Canadian Navy, gave a description of the stability and control of the Canadian naval icebreaker "Labrador." A paper by Mr. Owen H. Oakley and Mr. S. W. Lank dealt with nuclear powered icebreakers; Mr. A. Watson of the Institute of Marine Engineers, dealt with icebreaker operation in the St. Lawrence, the Great Lakes and the Arctic, and Rear-Admiral E. H. Thiele, of the United States Coastguards, discussed the problems in the operation of modern large icebreakers.

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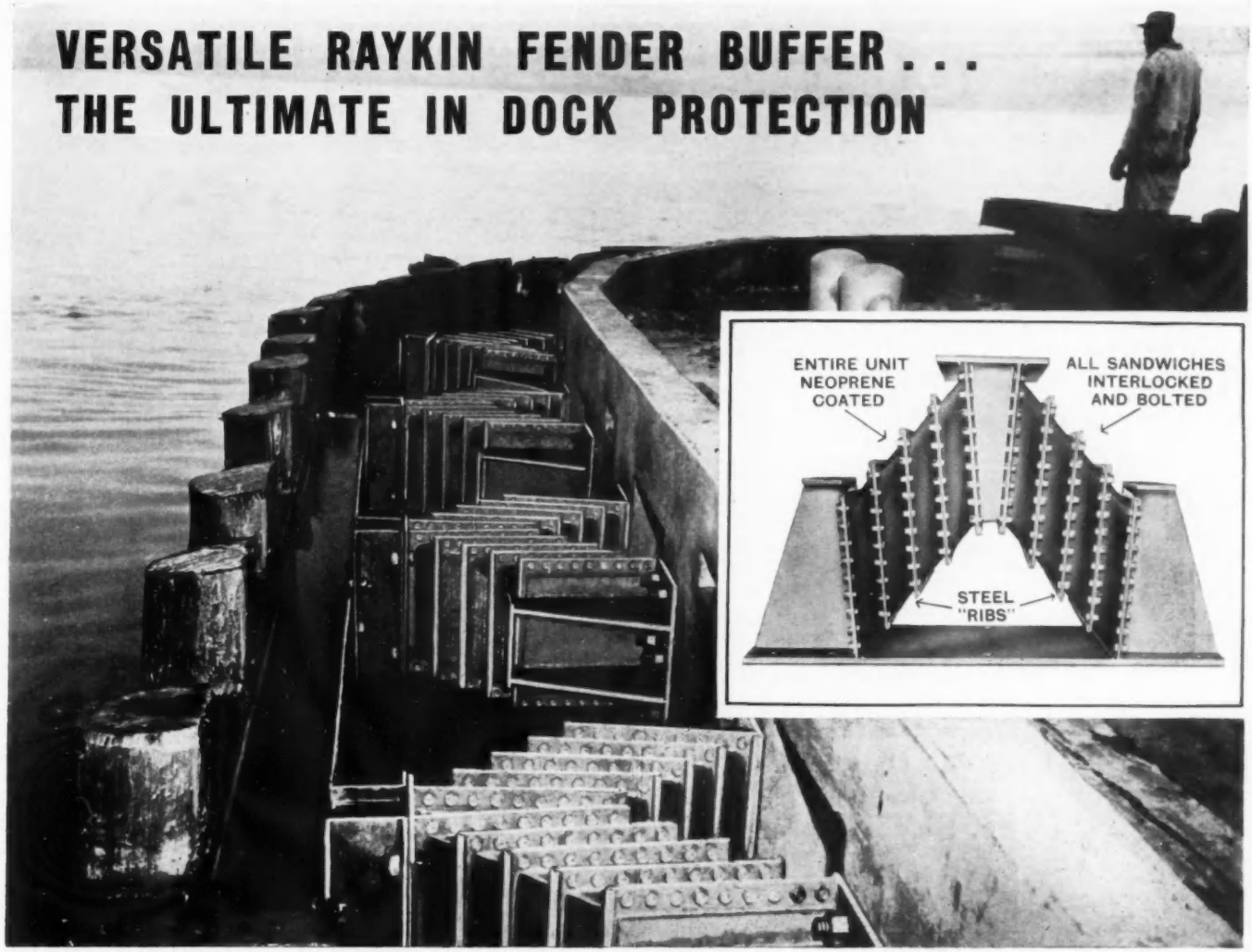

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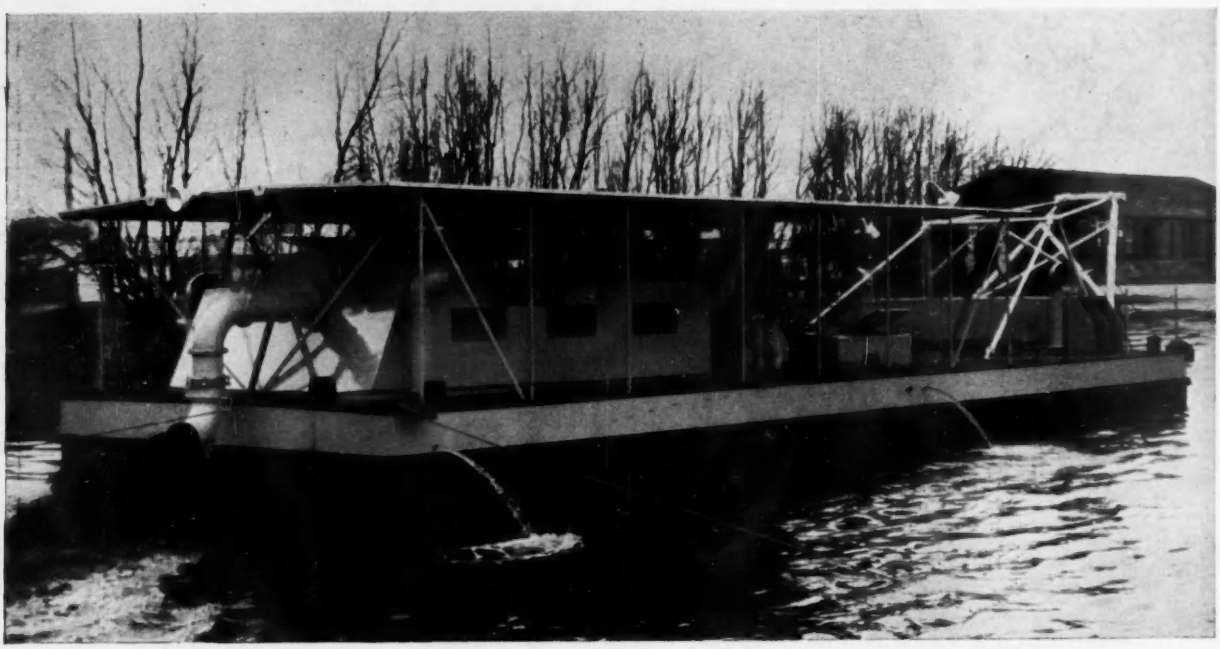

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STANDARD SIZES	ZC 17½	ZC 20	ZC 25	ZC 30	ZC 35
Length (metres)	10	12	14	17	19
Width (metres)	4	4,50	5	6	7
Depth (metres)	1,50	1,50	1,80	1,80	1,80
Draft app. (metres)	0,65	0,70	0,80	0,80	0,75
Max. cutter depth (metres)	3,50	5	6	7	8
Max. distance of discharge (metres)	250	500	750	900	1000
Max. height of discharge at max. distance (metres)	3	3	3	3	3
Mixture production at max. height and distance cbm/h.	300	400	620	900	1200

STANDARD SIZES	ZC 17½	ZC 20	ZC 25	ZC 30	ZC 35
*Percentage of soil in mixture	10-20	10-20	10-20	10-20	10-20
Soil production at max. height and distance cbm/h.	30-60	40-80	62-124	90-180	120-240
Diameter suction pipe (cm.)	20	25	30	35	40
Diameter discharge pipe (cm.)	17,5	20	25	30	35
Total Diesel power H.P.	85	155	259	374	487

** Note that the percentage of soil in the mixture depends on the nature of the soil and consequently the soil production will vary between the given figures.*

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Lake Superior Harbours

By COL. DESLOGE BROWN, District Engineer
(Superior), U.S. Army Corps of Engineers.

Lake Superior is a historic body of water. It was better known than any of the other Great Lakes to the early cartographers and was called various names by the first explorers. The French named it Superior because it was above the other Lakes. It is the largest, the coldest, the clearest and the deepest body of fresh water in the world. Its temperature does not change more than 6 or 7 degrees from one year to the next and it does not freeze, except round the edges in the winter, nor does the temperature of the main body rise above 40° in the summer. It is 400 miles in length, 160 miles in breadth and 1,000-ft. in depth with an area of 32,000 square miles.

In the 17th century a mission was established near Allouez Bay and fur trading posts grew up around it. The furs were shipped to New York and to Europe. Lumber and shingles were also shipped to the mining towns on the lake. In 1840 valuable copper and iron ore deposits were found in the range of hills around the Lake. However, because of the difficulty encountered in shipping the latter commodities through Sault Ste Marie, Michigan, which connects Lake Superior with Lake Heron, it was necessary to construct a canal with locks at that point. Work on the Soo Canal and locks was finished in 1855, permitting the passage of lake freighters into Lake Superior and this encouraged the setting up of a townsite near the Superior harbour. In 1881 a new era began with the completion of the Northern Pacific Railroad from the west. The proximity of the wheat country was another incentive to the growth of population.

At the end of the century the Soo Locks were deepened to 15-ft. or more in places. The Great Northern Railroad built a railway line to the port of Superior and also established a fleet of boats there. This was the real beginning of the Great Lakes package transportation.

There are eight major deep-draft harbours on Lake Superior. Six of them, Duluth-Superior Harbour, Two Harbours, Minn., Ashland, Wis., Marquette, Mich. and two private harbours, Silver Bay and Taconite Harbour in Minn. for shipping iron ore pellets processed from low grade taconite ore, are United States ports; and two, Port Arthur and Fort William are Canadian ports.

The largest is Duluth-Superior Harbour, about 4,430 miles from the Port of London, England. Duluth-Superior Harbour is the beginning of the St. Lawrence Seaway. The headwater of the St. Lawrence is the St. Louis River Basin which flows eastward down through Duluth to Lake Superior and eventually on to the St. Lawrence River.

Duluth-Superior Harbour is one of the finest natural harbours and one of the most important bulk traffic ports in the world. It consists of an outer and inner basin. The outer basin, known as Superior Bay, lies between the mainland and the natural sand and gravel breakwater, which is ¼ mile wide and about 9 miles long and extends from the Minnesota side to the Wisconsin shore. This spit of land protects the harbour from disturbing wave action in Lake Superior. The inner harbour consists of St. Louis Bay and St. Louis River. Originally, there was only one entrance to the harbour, located at approximately the present position of Superior Entry near the south end of Superior Bay.

Shallow draft vessel passing through Duluth piers into Duluth-Superior Harbour.

Duluth-Superior Harbour has a frontage of 49 miles behind established harbour lines; the harbour area is 19 square miles. There are 17 miles of dredged channels with widths ranging from 200-ft. to 600-ft., depths of 20-ft. to 25-ft. and 2 anchorage areas, one in the Duluth Harbour Basin, the other in the Superior Harbour Basin with ample room for anchorage of from 35 to 50 vessels.

Originally Superior Bay (the main harbour) and St. Louis Bay (the inner harbour) were wide expanses of shallow water with depths ranging from 5-ft. to 9-ft. and containing several small islands. The natural channel, created by the river current, was from 100-ft. to 500-ft. in width with depths varying from 8-ft. to 12-ft. Because of the varying depths of water at the entrance to the harbour, navigation was limited generally to 8-ft. or less, and during bad northeast storms this was decreased to 3 or 4-ft.

The first act performed by the Federal Government was the building of a lighthouse at the entrance of the harbour in 1857. Parallel timber crib piles were constructed at Superior Entry by the Corps of Engineers from 1867 to 1875.

The present Superior Entry piers and breakwaters were completed by the Corps of Engineers in 1914. The piers are 500-ft. apart; each has a concrete superstructure, supported by timber piling. The south pier is 1,584-ft. long and the north pier 2,096-ft. long. The rubble mound breakwaters converge, forming an arrowhead and providing a stilling basin of approximately 62 acres, which gives safe passage to vessels in the stormiest weather. Entering from the lake at Superior Entry, the channel depth is 32-ft. decreasing to 25-ft. at the Superior Bay end.

With the opening of the Canadian and Poe locks at the Soo in 1895 and 1896, respectively, and with the advent of larger bulk freighters with steel hulls, the channels in the Duluth-Superior Harbour were deepened to 20-ft. with additional depths provided in the lake approach channels. During the six-year period from 1896 to 1902 about 21,500,000 cu. yd. of material were dredged at a cost of about $2,000,000. The first shipment of iron ore from Duluth-Superior Harbour was made in October, 1892 and continued shipments soon established the harbour as one of the most important on the Great Lakes.

During the years from 1933 to 1935 the

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harbour was dredged to provide channel depths of 25-ft. to the ore docks and 22-ft. to the grain and coal docks. These depths were required to permit loading of the larger bulk freighters to their maximum usable draft.

The present Duluth Canal piers were completed in 1901. They consist of a concrete superstructure on a rock-filled timber crib substructure supported on piling and are robustly constructed. The piers are 1,734-ft. long and extend about 1,000-ft. from the shore line. The entrance channel has been improved to provide depths decreasing from 32-ft. at the lake end to 26-ft. at the harbour basin. The piers are 300-ft. apart but have been riprapped thus reducing to 240-ft. the width of channel having project depth.

Two iron ore carriers at the Great Northern Railway Ore Docks, Superior, Wisconsin.

The project depth at present in the major iron ore channels is 25-ft. and from 20-ft. to 23-ft. to the grain elevators and coal docks. It has been recommended in a survey report on improvements to Duluth-Superior Harbour that the major channels and anchorage areas be deepened to 27-ft. to correspond to the 27-ft. minimum controlling depths now available or under contract on the St. Lawrence Seaway project and the deepening of the Great Lakes connecting channels. This recommendation has been approved and is expected to be brought before Congressional legislators for consideration in the near future.

There is no tide on Lake Superior but there are rapid changes in currents at both entries due to seiches (fluctuations of lake levels caused by difference in atmospheric pressure). At the request of the Lake Carriers' Association an electronic current indicator was developed at the Corps of Engineers' research laboratory, the Waterways Experiment Station at Vicksburg, Mississippi. An indicator has been installed at the inner and outer end of piers at each entry to the harbour. A system of coloured lights, similar to those used for railway traffic signals, was devised. The light signals indicate to the pilot of an arriving or departing vessel the direction and strength of the current so he can use the proper precautions.

Another Corps innovation is the use of amber lights in the light standards, 100-ft. apart, on the Duluth Ship Canal piers, to distinguish the pier lights from the white city lights and for safety during foggy weather in lining up the vessel between the piers.

Duluth-Superior Harbour, which serves the cities of Duluth, Minnesota and Superior, Wisconsin, has had an annual marine tonnage of 64 million tons for the past 10 years and has ranked in tonnage second to New York for a number of years. The bulk freight movement consists primarily of iron ore, grain of all kinds, coal, limestone, scrap iron, and petroleum products. The fast turn-round of ships in the bulk trade is indicated by the average stay in Lake Superior ports of iron ore vessels of 6 hours and 18 minutes in 1957.

Smaller Harbours under Jurisdiction of Corps of Engineers

The other harbours in the St. Paul District, mentioned earlier, have been recommended for deepening to the 27-ft. controlling depths, primarily to provide for the large bulk domestic carriers built and under construction since World War II. The new ships are now built from 600 to 730-ft. in length, with cargo capacities increased from 13,000 ton loads to over 25,000 tons with the larger vessels requiring deeper harbour depths.

Two Harbours, Minnesota, 25 miles east of Duluth on the North Shore of Lake Superior, has an average annual marine commerce of 19,000,000 net tons. Deepening from the present project depth of 25-ft. and 26-ft. to 28 and 30-ft. has been recommended. This harbour is primarily for shipments of iron ore from the Mesabi Iron Range. Coal receipts are a secondary movement.

Ashland Harbour, Wisconsin, about 75 miles east of Duluth-Superior Harbour on the South Shore, is a well-protected natural harbour on the Chequamegon Bay and protected by the Apostle Islands at the entrance and a rubble mound breakwater 8,000-ft. long built by the Corps of Engineers. This harbour has 25-ft. depths to the ore docks and up to 21-ft. for the coal and lumber vessels at the west end of the harbour. Dredging up to 27-ft. has been recommended.

At Marquette, Michigan, the Corps of Engineers maintains two projects. One, called Presque Isle Harbour, has a breakwater 2,816-ft. long with harbour depths of 26-ft. at the entrance and 28-ft. in the inner portion. Deepening to 28-ft. and 30-ft. has been recommended. Marquette Harbour adjacent has a breakwater 4,500-ft. long and a harbour depth of 25-ft. to be deepened to 27-ft.

The Corps of Engineers has built and maintained a 25-ft. deep channel across Keweenaw Point 25 miles long with a minimum width of 300-ft. This waterway provides a place for refuge for large vessels midway on Lake Superior. Mooring piers for ships are provided at the upper and lower entrances.

The only U.S. harbour on Lake Superior at present with facilities for handling overseas general and bulk cargoes is the Duluth-Superior Harbour where grain storage is provided by 28 grain elevators with 63 million bushels capacity, and coal storage is provided at 14 coal docks with a capacity of 7,303,000 tons. Coal is distributed by rail to north-western states. There are seven ore docks (5 in Superior and 2 in Duluth) with highly specialised facilities for handling the various grades of iron ore. A typical dock is the Duluth, Missabe and Iron Range Railway Ore Dock No. 6 on the Duluth shore of St. Louis Bay. This dock is 2,304-ft. long, 84-ft. high and 75-ft. 5-in. wide. The operating platform (upper deck) carries four sets of tracks above the 384 loading pockets set in each side of the dock in pairs, each pocket having a capacity of 400 gross tons of ore. Loading from poc-

kets is accomplished by gravity, through chutes placed 12-ft. apart to coincide with the 12-ft. and 24-ft. spacing of the hatches on the ore carriers. Fastest loading record per hour in 1957 was 12,412 gross tons.

There are two cement elevators, four docks for handling scrap iron, four petroleum docks and miscellaneous docks for a total of 106.

New development in the harbour facilities due to the construction of the St. Lawrence Seaway is a 10 million dollar public marine terminal to handle general cargo under construction for the Seaway Port Authority of Duluth on a 120-acre site on the Duluth side of the outer harbour. It is scheduled for opening in May 1959. Modern facilities include two 90-ton travelling gantry cranes which in tandem will lift 180 tons.

Another project in the preliminary stage is a private marine terminal to be built by the International Duluth Seaport Corporation on a 135-acre site in the inner harbour. Facilities to be built include export grain terminals, tank storage farms and transit sheds.

The future of ports and harbours on Lake Superior due to the opening of the St. Lawrence Seaway for overseas trade seems bright. Improvements will be recommended as needed.

Winter Navigation on the Seaway

By HUET MASSUE
(General Manager, The Lower St. Lawrence and Gulf Development Association)

The recent opening of the St. Lawrence Seaway has made the St. Lawrence River one of the world's most important arteries of water-borne transportation. The improvements effected will permit 27-ft. draft vessels to reach Fort William in Canada, or Duluth in the U.S., some 2,300 miles away from the Atlantic Ocean. A wide door has thus been opened to one of the busiest shipping areas in the world, where 40 million people are to be found and from which, it is said, 65% of the export trade of the United States originates.

Various forecasts have been made about the traffic that will be handled by the Seaway. The Canadian Tolls Committee, of the St. Lawrence Seaway Authority, predicts that the tonnage handled should amount to 25 million tons in 1959 and some 50 million tons by 1968. In comparison, the commerce carried in 1955 by some of the leading American waterways was as follows:

		Million Tons			Million Ton
1.	Mississippi ...	94.0	5.	Illinois	21.0
2.	Delaware ...	87.0	6.	Hudson ...	20.2
3.	Ohio	71.5	7.	Columbia ...	19.8
4.	Monongahela ...	37.5	8.	Tennessee ...	10.0

In 1955 also, the commercial traffic through the Panama Canal was less than 45 million tons.

In view of the importance of the St. Lawrence River as an artery of commerce, the efforts that have been made throughout the years to facilitate and lengthen the navigation season, are well understandable. A 35-ft. deep channel, 1,500-ft. wide in the most dangerous places, is now available between Quebec and Montreal. The season of navigation in a normal year now extends over 200 days. An increasing number of more powerful icebreakers are regularly being used to prevent ice-jams along the 160-mile ship-channel between Quebec and Montreal and to help facilitate winter navigation through the Gulf and as far up the river as possible. In this regard, winter navigation will be further improved when the four icebreakers, now being built for the Federal Department of Transport, become available, three of medium size in 1959 and a larger one in 1960. It has been predicted that an all-winter channel to Montreal will some day become a reality. Whenever this happens winter navigation, possibly up to Quebec City, but surely from the mouth of the Saguenay River down to the sea, will have been established on a sound basis.

In this connection, it is of particular interest to note that navigating experience to date shows that the accident record of vessels penetrating the Gulf of St. Lawrence during the winter months has been practically devoid of any incidents. This experience, together with greater icebreaker assistance and other precautionary measures to navigate in ice, should induce marine underwriters to reduce premiums, which, in turn, would certainly encourage shipowners to participate in the increased movement of shipping in the Gulf of St. Lawrence region.

As a result of the extensive industrial and mining developments now taking place on the North Shore of the Lower St. Lawrence River, waterborne transportation originating or terminating at the local ports, has grown considerably in recent years. Amounting to about 4 million tons in 1952, the tonnage handled in 1957 reached 20.4 million tons, and was about 50% higher than the 14 million tons handled during the same year by the St. Lawrence River canals, between Lake Ontario and Montreal. It is predicted that by 1970, the tonnage handled by the Lower St. Lawrence and Gulf ports will reach 45 million tons.

Winter Shipments

So far, winter shipments to and from the region have been almost entirely confined to the export of newsprint from Corner Brook and from Dalhousie, in Chaleur Bay. In recent years a total of 180,000 tons was shipped during the four winter months. Occasionally paper has also been shipped in winter from Baie Comeau; this should soon become a regular feature when the 11,000-ton vessel with reinforced bows for ice navigation, now being built in Europe is completed in 1960. For the first time, Canadian British Aluminium Company Limited, also at Baie Comeau, has joined the group of winter shippers by exporting a few thousand tons of aluminium ingots and by importing a few thousand tons of raw materials. In future years, the volume of winter shipments handled by CBA should increase considerably as their annual production rises to 90,000 tons or more. Total requirements for raw materials in 1959 should amount to 250,000 tons, of which a large portion will have to be imported during winter months.

It is expected that these commodities will soon be joined by others and that by this autumn there will be shipments of grain to Europe from Baie Comeau. Winter shipments of beneficiated iron ore to foreign markets will soon be started from Port Cartier and from the port of Sept-Iles. By 1970, of the estimated 35

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million tons or iron ore expected to be produced on the North Shore and shipped yearly to foreign markets, it is likely that 20 million tons will be palletised or beneficiated ores with a 65% iron content.

On the basis that only beneficiated ore would be shipped in winter, and that shipments would be equally divided between the various months of the year, it is estimated that about 7 million tons of ore would be shipped throughout December, January, February and March of each year.

Industrial Evolution of the North Shore

The following points should help the reader to better appreciate the industrial potentialities of the area:—

(1) The area concerned called "North Shore" consists of a 400,000 square mile territory included between the Lower St. Lawrence River below the Saguenay, to the south; James and Hudson Bays to the west; Hudson Strait and Ungava Bay to the north, and the Atlantic Ocean to the east. Of that territory, approximately 300,000 square miles belong to the Province of Quebec and 100,000 square miles to Newfoundland.

(2) In this vast territory there are innumerable natural resources; wood, water-power, minerals of all kinds and more particularly of iron and titanium ores.

(3) The following developments are in hand:
   (a) At Baie Comeau docking facilities and grain elevators are being built with an initial projected capacity of 15,000,000 bushels.
   (b) At Shelter Bay, about 100 miles east of Baie Comeau a total of some $250 million is being spent on a development scheme to produce 8 million tons of beneficiated iron ore per annum. It is said that this will entail the yearly treatment of 20 million tons of crude ore.
   (c) North of Sept-Iles, work is starting on the development of two concentration plants estimated to produce 8,000,000 tons of ore and costing about $400.

(4) Within the next ten years, the development of some 4 million horsepower on the Manicouagan River, flowing into the St. Lawrence at Baie Comeau can be foreseen. It is expected that by 1970 6 million of the 16 million horsepower available on the North Shore will have ben harnessed. Also, as soon as there is sufficient demand, work will proceed on producing a further 4 million horsepower at a site on the Hamilton River, some 250 miles north of Sept.-Iles.

(5) All these developments are expected to require between 1950 and 1970 an investment exceeding $2,500 million, and the total value of production is expected to exceed $625 million by 1970.

(6) The population of the North Shore has been growing recently at an average yearly rate of over 10%. The present population of some 80,000 people is expected to total 150,000 by 1970.

Dredging the Great Lakes Channels

By Col. PETER C. HYZER
(District Engineer, Detroit, U.S. Army Corps of Engineers)

Amherstburg Channel

Work on the extension of the Seaway to the Great Lakes was started by the U.S. Army Corps of Engineers in the Amherstburg Channel of the Detroit River on May 28, 1957. This 145 million dollar Great Lakes Connecting Channels Project calls for the widening and realignment of channels and the deepening of all channels to depths varying from 27 to 30-ft. The project will involve the removal of 66 million cu. yds. of material and was authorised solely on the basis of present and prospective commerce on the Great Lakes without including commerce entering or leaving the Great Lakes through the St. Lawrence Seaway.

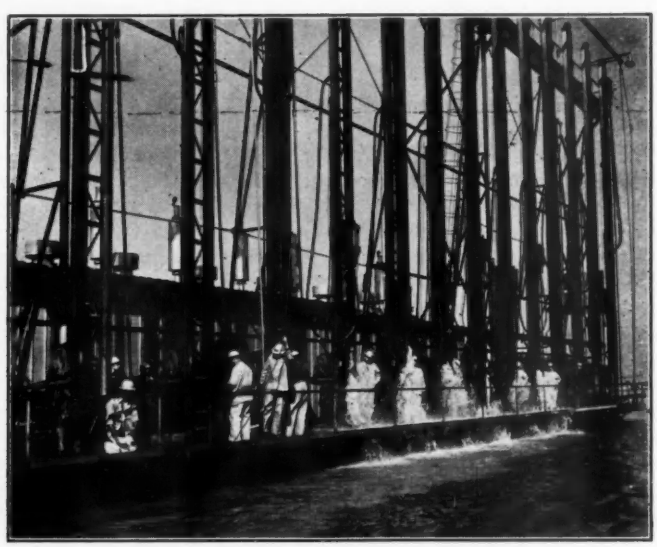
Work on the Amherstburg Channel is scheduled for completion in June, 1960; approximately the upper 6 miles of the contract was awarded to Marine Operators, and the lower 2 miles to Great Lakes Dredge and Dock Company, each using somewhat different equipment. About 3 million cubic yards of material are to be removed from this channel—mostly rock excavation.

Marine Operators is a joint venture composed of four Mid-West Contractors. Their contracts are for $16,322,857 and the entire area to be dredged is in stratified limestone rock. They are using interesting equipment. The main unit is the drillboat "Hornet IV"—160-ft. long and about 37-ft. wide. She is a sectional barge, fabricated by the Manitowac Shipbuilding Company (Wisconsin), shipped by rail to Ojibway, Ontario (opposite Detroit) in January, 1957. She is equipped with 20 drill frames 50-ft. high, drilling to about 35-ft. Seven air compressors operate the drills and other equipment. This is a new method of operation on the lakes.

"Hornet IV" works three 8 hour shifts. About seven drillers work at a time, moving from one drill to another. When all 20 holes are ready, the vessel is moved a distance of about 200-ft. by means of its four spuds, and the charge is exploded.

To provide accurate control three seismograph crews, employed by the Army Engineers, operate along the shore, recording every blast on film, and order decreased charges when desirable. Aboard the "Hornet," the water surface is seen to bubble up intensely for a few seconds, but the shock is not excessive. The full cycle of 20 blasts is completed and set off once every hour.

The "Hornet" is accompanied by "Samson," a steel scow,



Drilling in progress aboard the drillboat "Hornet IV." Concentration of air at the drilling point forces water and rock particles upward to the open end of sleeve.

175-ft. long and 65-ft. wide, rebuilt in 1957. She carries a 9W Bucyrus-Erie Monighan dragline having a boom radius of 150-ft. and a bucket capacity of 12 cubic yards.

The "Samson" deposits excavated material on a fleet of four flat steel scows, 149-ft. long, 40-ft. wide. Each has a capacity of 750 cubic yards of material.

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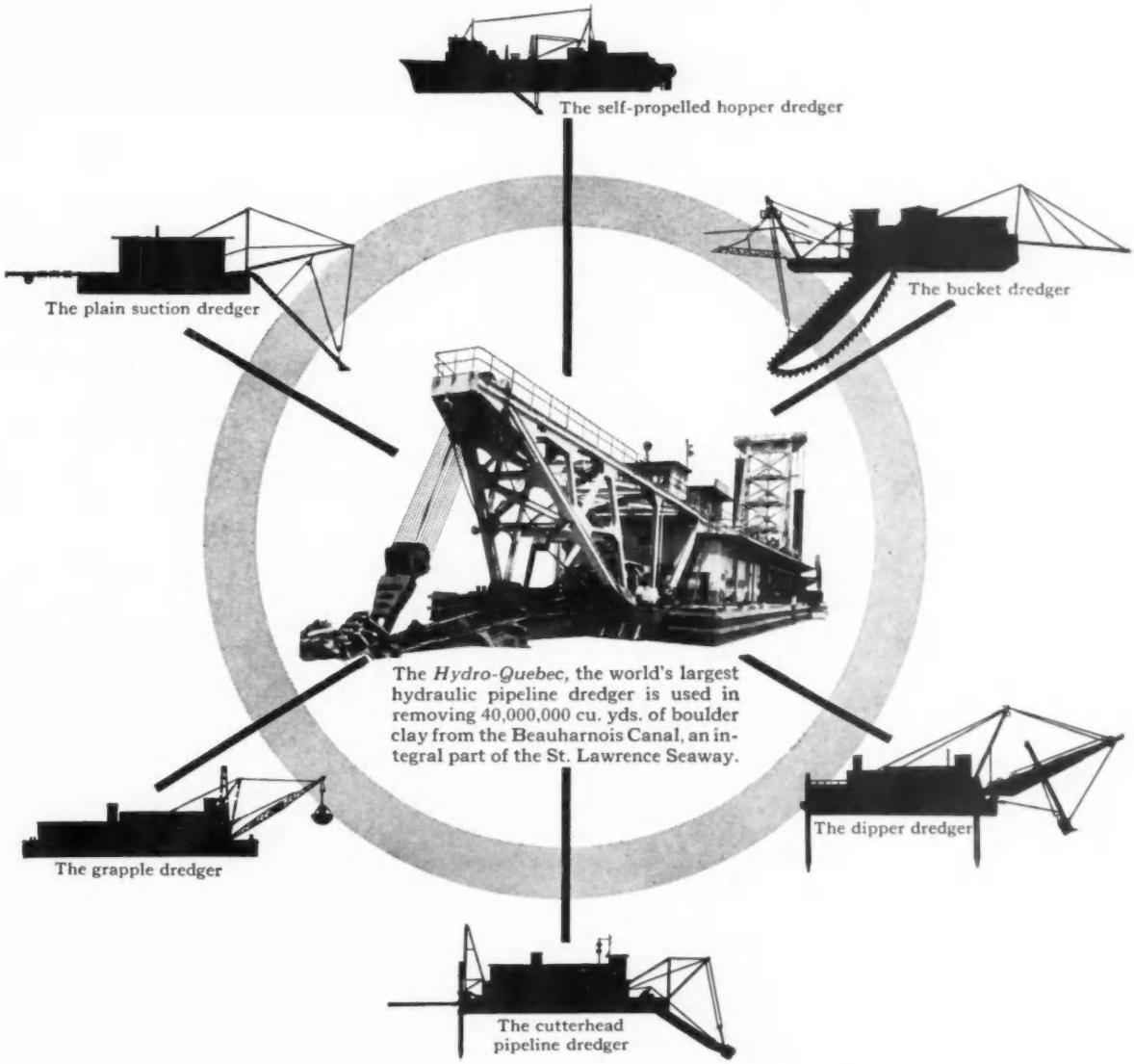
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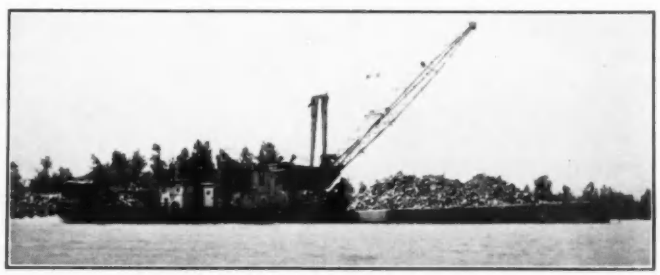
Excavated material is removed from the deck scows by a Manitowac 6 cubic yard model 4,500 caterpillar dragline. This is mounted on a compensating dike and its extension is now being built up, extending downstream of the channel. Another compensating dike about 6,000-ft. long is being constructed with



The tug "John Rohen Jr." pushing a loaded deck scow. Behind can be seen the drag line dredge "Samson."

the excavated material projecting toward the open Lake area at the lower end of the channel.

The Great Lakes Dredge and Dock Company contract is for $6,568,000, covering removal of an estimated 400,000 cubic yards of rock and a further 500,000 of earth. In a small area, covering the lower two miles where the river broadens into relatively open water at its mouth, no blasting is required; in other parts, removal of 4-ft. or so of rock under the overburden of clay and mud is necessary.

The company is using a method of operation long familiar in large and small projects on the lakes. The basic unit is the dipper dredge "Mogul" which is 156-ft. long and 43-ft. wide. Her bucket capacity is 12 cubic yards with a boom length of 60-ft. and a radius of 50-ft. She can dredge to a depth of 45-ft. with a 65-ft. dipper handle. Her lifting capacity is 300,000 pounds. Some boulders up to 16 cubic yards have been encountered on this work.

The "Mogul" works three shifts, and has a regular crew of 32. Excavated material is normally deposited in two bottom dump scows. These are 224-ft. long and 143-ft. wide and are constructed of steel, with 7 pockets having doors weighing 18 tons each. Each scow has a capacity of 1,539 cubic yards.

The principal dump area for excavated material lies in open water away from shipping lines. Tugs tow the scows to this area and release the material.

Headwaters of the Detroit River

At the head of the Detroit River, a straight job of excavation was completed in September and October, 1957, by the world's largest dipper dredge, "Paraiso," owned by the U.S. Government and operated by the Army Engineers. The work was primarily straightening the existing channel and deepening it in some segments, over a four mile stretch from Windmill Point to the foot of Clark Street in Detroit.

The "Paraiso" was built in 1913 for maintenance work on the Panama Canal. She has a 15 cubic yard bucket and can dredge to a depth of 50-ft. She is not self-propelled and is tended by Corps of Engineers' tugs; she has a crew of 17.

The total amount of excavation to be carried out in this area of the Detroit River is 697,000 cubic yards, and the "Paraiso" removed approximately 279,000 cubic yards of this material which was placed in dump scows and towed to dump areas about four miles away in Lake St. Clair.

Middle Neebish Channel—St. Marys River

The second phase of this project was started in June, 1957. The Middle Neebish work was bid for in sections—approximately 7½ miles of work was awarded to Price Brothers-McClung, Incorporated; 4 miles to Great Lakes Dredge and Dock Company and 2 miles to Dunbar and Sullivan Dredging Company. Approximately 3 million cubic yards of material will be excavated from this channel, and the work is scheduled for completion in 1959.

Price Brothers-McClung of Toledo, Ohio, was awarded a contract involving hydraulic dredging and amounts to $1,243,024. A total of 1,121,000 cubic yards of material was excavated by this contractor. Work was completed in September, 1958.

The Great Lakes Dredge and Dock contract for this work is for $10,816,320, covering the removal of an estimated 1,824,000 cubic yards of earth and rock. This contract is expected to be completed in June of 1959.

The Drill Boat "M-I" first employed by this contractor on the Amherstburg Channel and later moved to work in the Middle Neebish Channel is 140-ft. long and 35-ft. wide and has a displacement of 651 tons, light. The vessel is equipped with four standard drill frames, drilling to a depth of from 5 to 35-ft. Each frame is mounted and movable upon a common track.

The drilling equipment is steam-powered and oil-fired with compressed air used only to clean the drilling holes. The same basic steps of operation in drilling as previously described are being used.

After drilling operations are completed the 6 cubic yard dipper dredge, "War Horse," is used to remove the material. An oil-fired dipper dredge, the "War Horse" is 110-ft. long and 40-ft. wide, built in 1914, it is assisted by the 5 cubic yard dredge "53." Twenty-three men work three shifts.

These two dredges load the excavated material on four scows which have a capacity ranging from 812 to 1,539 cubic yards. The material is then towed to specially designated dump areas and deposited away from the navigation channel.

Dunbar and Sullivan of Detroit, Michigan, was awarded a contract amounting to $7,259,260, for the removal of an estimated 734,000 cubic yards of material.

The major unit employed by this contractor is the Drill Boat "J. M. Hassett," which has an overall length of 125-ft. and a beam of 32-ft. Employing 34 men on three shifts, she has three drill frames operated by three air compressors and was built in 1957. She is assisted by the 9 cubic yard Dipper Dredge "Omadhaun," which is 110-ft. long and 40-ft. wide, built in 1911, employing 19 men working three shifts. She has a maximum dredging depth of 25-ft. and a minimum of 10-ft.

Lake Nicolet—St. Marys River

Western Contracting Corporation of Sioux City, Iowa, was awarded a $2,816,370 contract in the autumn of 1958 for dredging approximately 4,617,000 cubic yards of material from Lake Nicolet in the St. Marys River. Work on this contract started during the spring of 1959 and is scheduled for completion in 1961.

St. Clair River

Great Lakes Dredge and Dock Company was awarded a $3,297,484 contract in 1958 for dredging approximately 2,038,000 cubic yards of material from a section at the foot of Lake Huron, and work on this is scheduled for completion in 1960.

Work Planned for 1959

Construction plans for this project during 1959 include the continuation or completion of existing contracts in the Amherstburg Channel of the Detroit River and in the Middle Neebish Channel of the St. Mary's River. Construction on the channel at the foot of Lake Huron will be continued. New starts will be made in the St. Mary's River and will include work at: Round Island Shoal, costing approximately $5 million, Vidal Shoals, costing approximately $2 million, and the angle course at the lower end of Bayfield Channel costing approximately $1 million.

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Dredging the St. Lawrence Seaway

Among the marine dredging firms which have been working on large contracts during the past 3½ years to prepare the 27-ft. deep channel for the St. Lawrence Seaway, the **McNamara Construction Co. Limited** has played a leading role. The Marine Division of this heavy construction firm, which has its headquarters at Toronto, Ontario, has completed the task of dredging 5,476,000 cubic yards of material to help make this vast inland waterway a reality. This impressive total can be broken down into 4,067,000 cubic yards of material, consisting of glacial till, mud, silt and sand, and 1,409,000 cubic yards of rock which had to be drilled and blasted before it could be dredged.

Of the total dredged, 2,731,000 cubic yards of material were removed from the actual Seaway channel, while 2,745,000 cubic yards were removed from locations directly associated with the Seaway, such as the lower St. Lawrence River leading to the Seaway channel, and the Toronto Harbour and Western Gap where shipping using the Seaway will berth.

In carrying out this large volume of marine drilling and dredging work the Marine Division used a fleet of 6 derrick dredges, 5 dipper dredges, 3 hydraulic dredges, 2 hopper dredges, 11 tugs, 18 dump scows and 6 drill boats.

The locations on the Seaway proper at which this equipment was used to deepen the channel to 27 or more feet were Port Colborne, Ontario, the North Channel of the St. Lawrence River at Cornwall, Ontario ; Horseback Shoal, Renshaw Island and Stanley Island in the wide portion of the river below Cornwall known as Lake St. Francis, and at Beauharnois and Chateauguay in another wide portion of the river known as Lake St. Louis, near Montreal.

At Port Colborne the McNamara drill boats and dredges drilled, blasted and dredged 850,000 yards of rock from the bottom of the Welland Canal to deepen it to Seaway depth. The work was carried out over a distance of 8,700-ft. in the canal, and while the drill holes were being sunk and the shattered rock dredged from the bottom, the huge grain and ore carriers and other large lake boats passed by continuously. This project took just two years to complete and was finished in mid-October, 1958.

Similar work is being carried out in the North Channel of the St. Lawrence at Cornwall. This project of removing a total of over 500,000 cubic yards of rock and other material will be completed this summer.

Dredging in progress in the Welland Canal at Port Colborne.

The clamshell dredge "Hamilton 56" at work in Wellington Canal near Port Robinson.

Downstream from Cornwall, where the St. Lawrence widens out to form Lake St. Francis, the McNamara dredges have dredged 108,000 cubic yards of spoil from the bottom near Renshaw Island, 172,000 yards at Horseback Shoal and 335,000 yards off Stanley Island.

Still closer to the Seaway entrance at Montreal, the company's fleet has been busy off Beauharnois and Chateauguay in Lake St. Louis dredging 762,000 yards of glacial till from the Seaway channel.

The Marine Division has also been engaged in other major dredging projects which are directly related to Seaway work. Offshore from the town of Champlain, near Three Rivers, Quebec, the dredges this summer will complete 1,000,000 cubic yards of dredging at Champlain Curve. This operation will straighten and deepen the channel which will be used by shipping proceeding up the St. Lawrence for Montreal and the Seaway. The contract is being carried out for the Federal Department of Transport.

At Toronto, Ontario, five of the McNamara dredges have concentrated on the task of dredging rock, mud, silt and sand from the Western Gap and Inner Harbour to deepen them to Seaway specifications. This project began in May, 1957, the drilling phase was completed in the autumn of 1958 and the dredging work was completed in May, 1959. A total of 1,400,000 cubic yards of mud, sand and silt and 345,000 cubic yards of rock were removed to enable shipping drawing up to 27-ft. of water to use the entrance and the harbour. This work was carried out by the Federal Department of Public Works for the Toronto Harbour Commission.

The Company has also been doing considerable dredging to improve smaller harbours on the Great Lakes—harbours which in the future could become ports of call for the bigger vessels which the new Seaway facilities will attract to Canada. At Oshawa, near Toronto, the dredges removed 144,00 cubic yards of material to deepen the harbour to 21-ft., while nearby, at Whitby, 154,000 cubic yards of material have been removed from the harbour. From 1955 to 1957 the Marine Division dredged 1,145,000 cubic yards to improve the harbours at the important Great Lakes ports of Fort William—Port Arthur on Lake Superior.

One of the most important jobs on the St. Lawrence Seaway was the task of enlarging and deepening the existing channels from Montreal to Lake Erie. A large portion of this work was undertaken with dredging equipment. Dredging on this project was particularly difficult due to the presence of large quantities of glacial till and also because of the necessity of removing extremely thin layers of rock from certain sections of the Welland Canal. Such obstacles as these were encountered by the **J. P. Porter Company, Ltd.** who were awarded four dredging contracts in this area.

The first of these involved the removal of some 320,000 cubic yards of clay and broken rock from Port Weller Harbour with

their diesel-electric suction dredge "Shuniah." However, although this dredge was able to remove most of the material from the harbour, it encountered, in certain sections, solid rock which it could not excavate.

Some time after the "Shuniah" had finished the normal dredging, therefore, the St. Lawrence Seaway Authority called for tenders for the removal of the 37,000 cubic yards of rock which remained above the required Seaway grade. The Porter Company was again awarded the contract and proceeded to remove this rock, which extended an average of only 8-in. above grade. For this an 8 cubic yard dipper dredge "delver" was used together with a drillboat "J.P.P. No. 8" equipped with two 6-in. pneumatic drills.

The Company obtained its third contract in August 1958 and will complete it during the summer of 1959 with their 5 cubic yard clamshell dredge "Hamilton 56." This project contains a large number of small scattered dredging areas and extends for a distance of ten miles along the southerly end of the Canal.

The fourth contract is, like the first two, in the Port Weller area. It involves the removal of a number of scattered shoals from the channel just outside the harbour limits and it is to be completed during this summer.

The first Seaway dredging work undertaken by the Company was at Chimney Island, three miles east of Prescott, Ontario. This channel improvement contract was awarded to the Canadian Dredge and Dock Company Ltd. by the Ontario Hydro Electric Power Commission who sublet approximately 500,000 cubic yards to the Porter Company. The work at Chimney Island included the actual removal of a large portion of the island.

At Cardinal, Ontario, the Company participated with Canadian Dredge in a joint contract involving the removal of 2,000,000 cubic yards of material, the work being carried out by an 8 cubic yard dipper dredge. Dredging the upstream approaches to Iroquoise Lock in the International Section of the Seaway; the removal of Iroquoise Point, located just west of the new dam at Iroquoise; the removal of sections of the bank of the old St. Lawrence Canal, as well as portions of Ogden and Canada Islands are other works carried out by the Company.

The most easterly of their Seaway dredging contracts was located on the Beauharnois Power Canal in Quebec. It involved the removal of approximately 33,000 cubic yards of Potsdam sandstone from the approach to the upper Beauharnois Lock for United Waterways Constructors Ltd., who were the main contractors for the construction of the Upper Lock. This work was completed in the spring of 1959.

Glacial till was encountered on almost all of the contracts between Chimney Island and Morrisburg and its presence reduced the production of all of the large dipper dredges by as much as 50%. Glacial till is an extremely dense mixture of sand, clay, gravel and boulders and has a weight of the same order as concrete. The toughness of this spoil may be gauged from the fact that many of the Seaway contractors operating on shore found it necessary to drill, and blast, prior to excavation with large power shovels.

Dredging the Beauharnois Canal

The 15 mile long Beauharnois Canal, between the towns of Valleyfield and Beauharnois in the Province of Quebec, was first constructed in 1929 as a hydro-electric development, and improvement of the Canal and power plant has been gradual since that date, with dredging being used as the primary means of excavation. However, since the 2nd World War the demand for electric power has greatly increased, which has required the capacity of the canal to be enlarged at a quicker rate than originally planned. The Quebec Hydro-Electric Commission therefore appointed engineers to study the problem of how to speed up dredging in the Canal to keep up with the increasing power demand.

At that time a pipeline hydraulic dredge, and a dipper dredge making disposal through a scow-mounted crushing and pumping unit, were both in operation in the Canal, but their full output was proving insufficient.

Apart from its hydro-electric use the Beauharnois Canal has also become an integral part of the St. Lawrence Seaway. The construction of ship locks have made it the connecting link between Lake St. Francis and Lake St. Louis, and these will allow ocean-going vessels to navigate the Canal instead of passing through two older and more shallow canals. A channel 600-ft. wide by 27-ft. deep has been dredged for the sea-going ships in the 3,300-ft. wide Canal, which for generating electric power makes use of the 80-ft. drop in the water level between the two lakes. The navigation locks have been constructed to accommodate this variation in water level without interference to the power plant.

The Commission requested assistance from the Ellicott Machine Corporation of Baltimore, Maryland, U.S.A. in designing a new dredging unit and this Company supplied the hydraulic dredging machinery and also acted as consulting engineers on the construction of the dredge and on its fitting-out at the Marine Industries' Shipyards in Sorel. The contract between the Beauharnois Light, Heat and Power Company and the Ellicott Machine Corporation was signed on March 30st, 1951 and the dredge was handed over to her owners and put to work in December 1952. It was named the "Hydro-Quebec."

Cutter type hydraulic dredge "Hydro-Quebec." To the left can be seen the floating discharge pipe.

The dredge is of the latest type and designed both for the specialised service on the Canal and for the extreme versatility expected of modern equipment. It is a cutter type hydraulic dredge, and has an immense underwater rotating cutter at the end of a dredging ladder which cuts and agitates the materials to be removed. By means of a large pump the dredge sucks up the agitated materials and pumps them to spoil areas ashore through a floating discharge pipe. The dredge propels itself round its work area on pointed spuds and is completely independent of other craft during the dredging operations, performing the double function of digging materials underwater and transporting

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them hydraulically to spoil areas ashore. It can also move to various work areas in the Canal by means of powerful "pull-back" and warping winches. Its principal dimensions are:

Length Overall	280 feet
Breadth Overall	58 feet
Depth of Hull	15 feet
Maximum Draft	9 feet
Total Displacement (long tons) ...	2,500 tons
Inside Diameter of Discharge Pipe	36 inches
Maximum Digging Depth	50 feet
Total Connected horsepower ...	12,180 h.p.
Dredging Pump Motor	8,000 h.p.

Without resorting to blasting, the dredge will dig "boulder clay," which is a heavy, sticky, type of marine clay laced with glacial boulders, and is considered one of the most difficult to cut and transport hydraulically. Therefore, in the design and building of the unit every consideration was taken to incorporate the most modern developments for hydraulic dredging work and while the dredge has much intricate machinery, the arrangement is such as to insure the most accurate and expeditious dredging. Great strength and endurance of machinery units, hull and agitating ladder, were of special importance as well as high resistance to abrasion.

The hull of the dredge is of welded steel and is designed so that its width can be reduced to allow passage through Canal locks by the removal of side sponsons. Structural steel trusses are located on each side of the centre hull section and run the entire length of the hull from ladder well to the stern of the dredge and furnish strength and stiffness to the hull. The structural steel spud frame also ties into and forms part of the hull truss framework, and a structural steel "A"-frame is extended forward of the hull and carries the sheaves for the ladder-hoisting arrangement.

The main dredging pump is of a special, heavy duty, centrifugal single-suction type. The pump is completely lined with special alloy abrasion-resistant steel.

At the working end of the dredge is the mammoth 26-ton rotating cutter head of the spiral-blade type with renewable teeth. This cutter is mounted on a ladder about 85-ft. long which weighs approximately 375 tons.

The dredge is electrically powered with current supplied from shore by submarine cable direct from the Beauharnois plant, at 13,800 volts, 3 phase, 60 cycle. The dredge pump motor is operated direct off of the 13,800 volt line and three 600 KVA transformers deliver current at 2,400 volts to the cutter motor M.G. Set and to the hauling and hoisting machinery M.G. Set, while a fourth transformer delivers current at 600 volts to an auxiliary power distribution switchboard. In addition to this a 125 KW diesel engine-driven generator set is provided to supply emergency current for operating various auxiliaries and lighting system, and also for raising of the ladder and spuds at reduced speed in the event that power from the shore is disconnected. Lighting equipment is installed to provide adequate illumination for all machinery spaces, compartments, and powerful floodlights are placed at the bow and stern to provide illumination for the operator to see the spuds and dredging ladder during night operations.

Speed control of the dredging pump is accomplished at constant torque by means of a liquid slip regulator and speed control of the cutter is by a combination of variable voltage and amplidyne motor control.

The dredge does not have sleeping accommodation for the complete crew. However, a steel upper deck house is provided in which there are three staterooms and offices, a wash room, and a utility room for officers. In addition, another wash room for crew is located on the main deck.

A raised control room is completely fitted out with the most modern types of controls and operating equipment. From this vantage point the operator can control the dredge pump motor, the cutter motor and the winch motors as well as the pneumatic controls for the clutches and brakes of the various winch units. All controls are centrally located on a control stand within easy reach of the operator. Dredge pump vacuum and pressure gauges, both indicating and recording, as well as instruments to show electric inputs to various motors and motor speeds, are also located in the lever room. All operations of the dredge are directed by telephone, radio or signals from the lever room, where the operator has clear visibility in all directions.

A new and unique feature of the dredge is that the suction line at the pump is arranged with a quick opening bottom drop clean-out cover pneumatically operated, to facilitate clean-out operations at the pump with minimum delay.

It is estimated the "Hydro-Quebec" will be removing some 40 million cubic yards of boulder clay from the Canal.

Seaway Regulation for Radio Communications

In paragraph 3-1 of "Circular No. 3" issued under the "Seaway Regulations" of The St. Lawrence Seaway Authority, it is recommended that vessels be equipped with V.H.F. (very high frequency) in addition to the required M.F. (medium frequency) radio-telephone equipment. The radio transmitter should have sufficient power output to enable the vessel to contact the Authority radio stations from a distance of 25 miles.

At the Annual Meeting of the International Chamber of Shipping, held in London in April, 1959, it was suggested that a comprehensive memorandum on the radio communication requirements for the St. Lawrence Seaway would be of value to constituents and on April 29th, 1959, the following statement was issued on the requirements:

All passenger steamships more than sixty-five feet in length and all other steamships of 500 gross tonnage or upwards, whether registered in Canada or not, when plying on the Great Lakes or on the River St. Lawrence above the lower exit of the Lachine Canal and the Victoria Bridge at Montreal, shall be fitted with a satisfactory radio-telephone installation and shall have on board a valid Radio Inspection Certificate.

This Regulation was taken from the Canada Shipping Act, Ship Station Radio Regulations, Part III.

A "satisfactory radio-telephone installation" is defined in the Canada Shipping Act, Ship Station Regulations Part I as a radio-telephone installation complying with the Regulations under Section 414 of the Act.

Ship Station Radio Regulations, Part II, are issued pursuant to Section 414 of the Canada Shipping Act. Briefly the main requirements are:

a) Transmitting and receiving radio-telephony on 2182 Kc/s and at least one other frequency (i.e., 2003 Kc/s).
b) The Transmitter should deliver at least 50 watts of unmodulated carrier power into an aerial of average characteristics.
c) The main operating positions should be located on the bridge.
d) The receiver must be capable of working a loudspeaker when the received carrier is as low as 10 microvolts per metre.
e) In passenger ships over 1,000 G.R.T. there must be an auxiliary source of power for the R/T installation.
f) The operating controls should be illuminated by a reliable light.

A steamship that enters the Great Lakes or on the River St. Lawrence above the lower exits of the Lachine Canal and the Victoria Bridge at Montreal for not more than two voyages in any calendar year shall be deemed to comply with the requirements given above if:

a) there is on board the ship a radio-telephone installation meeting the radio frequency requirements of the Ship Station Radio Regulations Part II, for ships plying in those areas.
b) that equipment meets the technical requirements of either the Ship Station Radio Regulations Part II of Chapter IV of the Regulations Annexed to the International Convention for the Safety of Life at Sea, 1948, and
c) the ship is carrying a valid Safety Radio-telephony Certificate issued by the country to which she belongs.

The full text of the Canada Shipping Act, Ship Station Radio Regulations, can be obtained from the Department of Transport, Ottawa.

In addition to the 2 Mc/s radio-telephone equipment which is compulsory, the Seaway Administration recommends that vessels be equipped with V.H.F. radio-telephone equipment to communicate on 156.6, 156.7 and 156.8 Mc/s with shore radio-telephone stations when transiting the Locks and Canals.